

ANNALS of SURGERY

A MONTHLY REVIEW OF SURGICAL SCIENCE AND PRACTICE

Also the Official Publication of the American
Surgical Association, the Southern Surgical
Association, Philadelphia Academy of
Surgery, and New York Surgical Society

VOLUME 111
JANUARY—JUNE
1940

CASSELL & COMPANY LIMITED, LONDON
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VITAMIN C STUDIES ON SURGICAL PATIENTS

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IN 1919, Aschoff and Koch¹ expressed the belief that in scurvy the primary deficiency consisted in a lack of or faulty development of intercellular cement substance. That vitamin C is the specific agent of importance in the formation of intercellular substance was pointed out by Wolbach and Howe,¹³ in 1926. Menkin, Wolbach and Menkin,^{7, 14} later, observed that when vitamin C was given to scorbutic animals, the amount of intercellular substance laid down in the tissues, as judged by microscopic sections, was in direct proportion to the amount of vitamin C given.

More recent work by Lanman and Ingalls⁶ has shown that the presence of scurvy in guinea-pigs interferes with wound healing, and suggested that a vitamin C deficiency might be of importance in clinical surgery. They measured the strength of healing wounds in the abdominal wall and in the stomach of normal and scorbutic guinea-pigs, by inflation of the abdominal cavity or stomach with air under controlled pressure. They found that while the abdominal wounds in normal animals ruptured at an average pressure of 160 Mm of mercury, the wounds in scorbutic guinea-pigs ruptured at an average pressure of 65 Mm. The stomach wounds broke at 70 Mm of mercury in the normal animals and at an average of 30 Mm in the guinea-pigs with scurvy.

The present study was undertaken to determine whether vitamin C depletion, as indicated by its concentration in the blood plasma, could be shown to exist in surgical patients. We have also studied the behavior of vitamin C in the body during the postoperative period to detect any changes which might occur that would clarify the rôle of vitamin C during the active healing process.

Determinations of the vitamin C content of the blood plasma have been made on 13 normal controls and on 188 patients. Most of these determinations were made by titration with indophenol, using the method described by Pijoan and Klemperer.⁹ In some of the later work, the modification of this

method for use with the photo-electric colorimeter, as described by Mindlen and Butler,⁸ was employed. When the concentration of cevitamic acid was great enough so that all the dye would be reduced, the metaphosphoric acid filtrate was diluted 1:10 with 2.5 per cent metaphosphoric acid and the calculations modified accordingly. At the time that the change in method was made, duplicate determinations were done, using both methods. A close correlation in the determinations was found, the photo-electric colorimeter giving usually slightly lower readings.

Since this work was started, a number of reports have appeared in the literature containing similar determinations on groups of patients suffering from various disease conditions. These are in general agreement with our studies.

From the work of various writers it would appear that an individual who is in a state of "saturation" with respect to vitamin C will show a fasting blood plasma level of about 1.3 mg per 100 cc of plasma, or slightly higher. An increase in the vitamin C intake fails to raise this level, and a large proportion of the excess vitamin appears in the urine. This optimum state, while theoretically the ideal one, is certainly attained in normal life by only a small proportion of the general population.

It is agreed that a fasting blood plasma level of under 0.5 mg per cent is definitely abnormal and that the presence of such a level indicates that the vitamin C in the body tissues has been markedly and perhaps dangerously depleted. In clinical scurvy the plasma vitamin C level is usually 0.1 mg per cent or lower. The range between 0.5 mg per 100 cc and "saturation" must, at the present stage of our knowledge, be considered normal, although it is evident that many individuals falling within this range show varying degrees of partial depletion, below the optimum "saturation" level.

Ingalls and Warren⁵ studied 20 patients with gastric and duodenal ulcers. They found their average blood plasma level to be 0.29 mg per cent with a range from zero to 1.15 mg per 100 cc. Wright and his coworkers¹² have reported blood levels on 49 patients with an average of 0.62 mg per cent and a range from 0.27 mg to 1.54 mg per cent. Faulkner and Taylor² studied 165 patients, of whom 95 had infection and 70 were free from infection. The average for the first group was 0.59 mg per cent with a range from 0.10 mg to 1.19 mg per cent, and for the patients without infection, the average was 0.96 mg per cent, with a range of 0.11 mg to 2.42 mg per cent. Rhinehart and his coworkers¹⁰ studied 55 cases of active rheumatoid and "rheumatoid type" of arthritis, 13 patients with gonorrheal arthritis and 12 cases of hyper-trophic arthritis. Their control group was composed of 120 medical students. The controls showed an average blood level of 0.7 mg per cent, with a range of 0.22 mg to 1.45 mg per cent. Of this group, 26.6 per cent were below 0.5 mg per 100 cc and 4.2 per cent below 0.3 mg per cent. Of the 55 patients with true rheumatoid or "rheumatoid type" arthritis, 89 per cent were below 0.5 mg per cent, and 74.5 per cent under 0.3 mg per 100 cc. The average for this group was 0.24 mg per cent. The 13 cases of gonorrheal arthritis had an average level of 0.22 mg per cent, with a range of 0.09 mg to 0.64 mg

per cent, while the distribution for the 12 patients with hypertrophic arthritis was above that for the normal controls

In using the fasting blood plasma level of vitamin C as an index of the degree of saturation or depletion of a given individual, certain facts must be kept in mind. A change in the vitamin C intake, particularly when it is considerably increased, may cause a change in the plasma content, which is out of proportion to the actual degree of saturation of the body as a whole. In other words, we feel that it is possible, by means of large doses of cevitamic acid, to raise the plasma content to a "saturation" level without obtaining complete tissue saturation. This is shown by the fact that the plasma level falls sharply when the administration of excess cevitamic acid is stopped.

Our 13 normal controls showed a blood plasma content varying from 0.77 mg to 1.62 mg per cent, with an average of 1.24 mg per cent. In the series of 188 patients on whom fasting determinations were made, the average blood plasma level was 0.43 mg per 100 cc, with a variation from zero to 1.89 mg per cent. Of the entire series 126, or 67 per cent, were found to be below 0.5 mg per 100 cc, and may be considered definitely abnormal with respect to their vitamin C metabolism.

TABLE I
BLOOD PLASMA CEVITAMIC ACID DETERMINATIONS ON 188 CASES

Group	Number of Cases	Average Plasma Cevitamic Acid Mg per 100 Cc	Range Mg per 100 Cc
Pulmonary tuberculosis	7	0.40	0.04-0.85
Ulcerative colitis	10	0.54	0.04-0.97
Osteomyelitis	10	0.40	0.07-0.83
Carcinoma of stomach	18	0.27	0.04-0.61
Carcinoma other than gastric	19	0.33	0.02-0.89
Arthritis	23	0.37	0.04-1.22
Gastric and duodenal ulcer	34	0.34	0.00-1.06
Miscellaneous	67	0.57	0.00-1.89
Totals	188	0.43	0.00-1.89

To determine whether the type of disease determines the degree of depletion of vitamin C, the patients were divided into several groups. These are shown in Table I. That the average blood level of vitamin C in patients with gastric or duodenal ulcers is low has been pointed out by several writers. The point to be emphasized is that the average level in several of the other groups is of the same order of magnitude as in the group of ulcer patients, so that an equal degree of vitamin C depletion is found, for example, in patients with carcinoma, regardless of its location, and arthritis. The patients with pulmonary tuberculosis and osteomyelitis have only slightly higher average levels. The miscellaneous group shows a somewhat higher average than the others. This is due to the fact that it includes a number of patients with benign conditions whose blood cevitamic acid levels were relatively normal.

It is obviously impossible to make direct determinations on the tensile strength of the healing wound in normal postoperative patients, and it was

felt that such observations made at autopsy would be affected by so many other variable factors that they would be unsatisfactory

In an attempt to obtain data which might lead to information on this subject, we have followed the plasma level of cevitic acid on a number of patients before and after operation. As shown in Chart 1, there is in most cases a definite, although sometimes transient, drop following operation. It seems to be more marked when the initial level is higher, and its degree seems to be somewhat dependent on the extent of the surgical procedure.

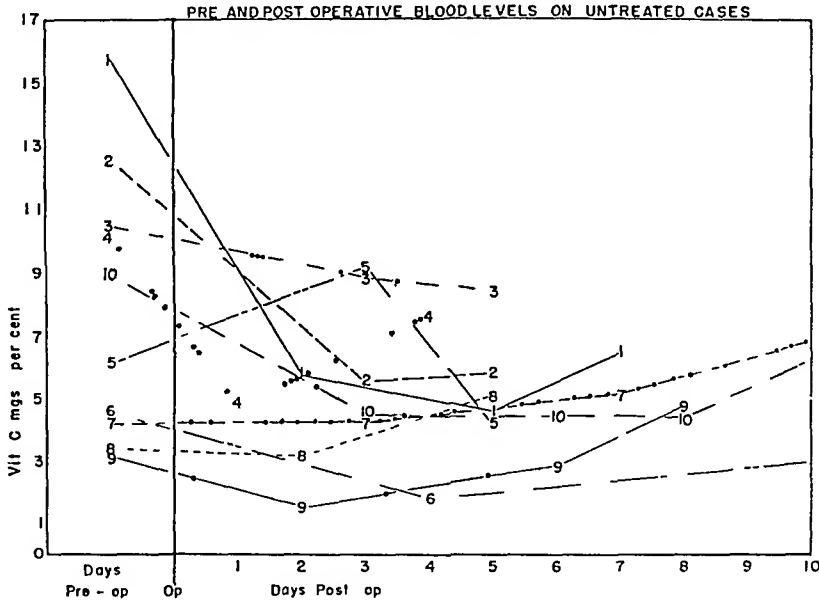


CHART 1—Blood vitamin C determinations on ten patients before and at various intervals after operation are shown. Most of them show a definite drop in the blood vitamin C level after operation. This seems more marked when the initial level is higher and its degree seems to be somewhat dependent upon the extent of the surgical procedure. The operative procedures on these patients numbered to correspond with the numbers on the graph are: (1) Lobectomy, (2) Incision and drainage of chronic empyema, (3) Hemorrhaphy, (4) Cholecystectomy, (5) Hemorrhaphy, (6) Abdomino-perineal resection of rectum, (7) Gastric resection, (8) Posterior gastro-entrostomy, (9) Gastric resection, (10) Gastric resection.

Eight patients were followed carefully before and after operation with repeated determinations of blood and urine. No supplementary vitamin C was given to these patients. The results of these studies appear in Chart 2. The urinary cevitic acid was determined by indophenol titration, using the method described by Harris, Ray and Ward.⁴ It must be kept in mind that the accuracy of this method is limited by the presence of other substances in the urine which will reduce the dye. These studies have been included, however, because they seem of interest. They fail to demonstrate any increase in urinary excretion following operation, such as has been described by Geissendorfer.³ It is interesting that the two patients with pulmonary tuberculosis excreted an amount of cevitic acid which is much larger than one would expect, considering their relatively low blood levels.

The consistent, although sometimes slight, fall in the blood cevitic acid observed after operation aroused our interest, particularly since we could not

account for a lowering of the blood level on the basis of increased excretion. Since vitamin C is known to be of importance in tissue repair, any evidence of a change in behavior, during a time when active healing is occurring, suggested various interesting possibilities.

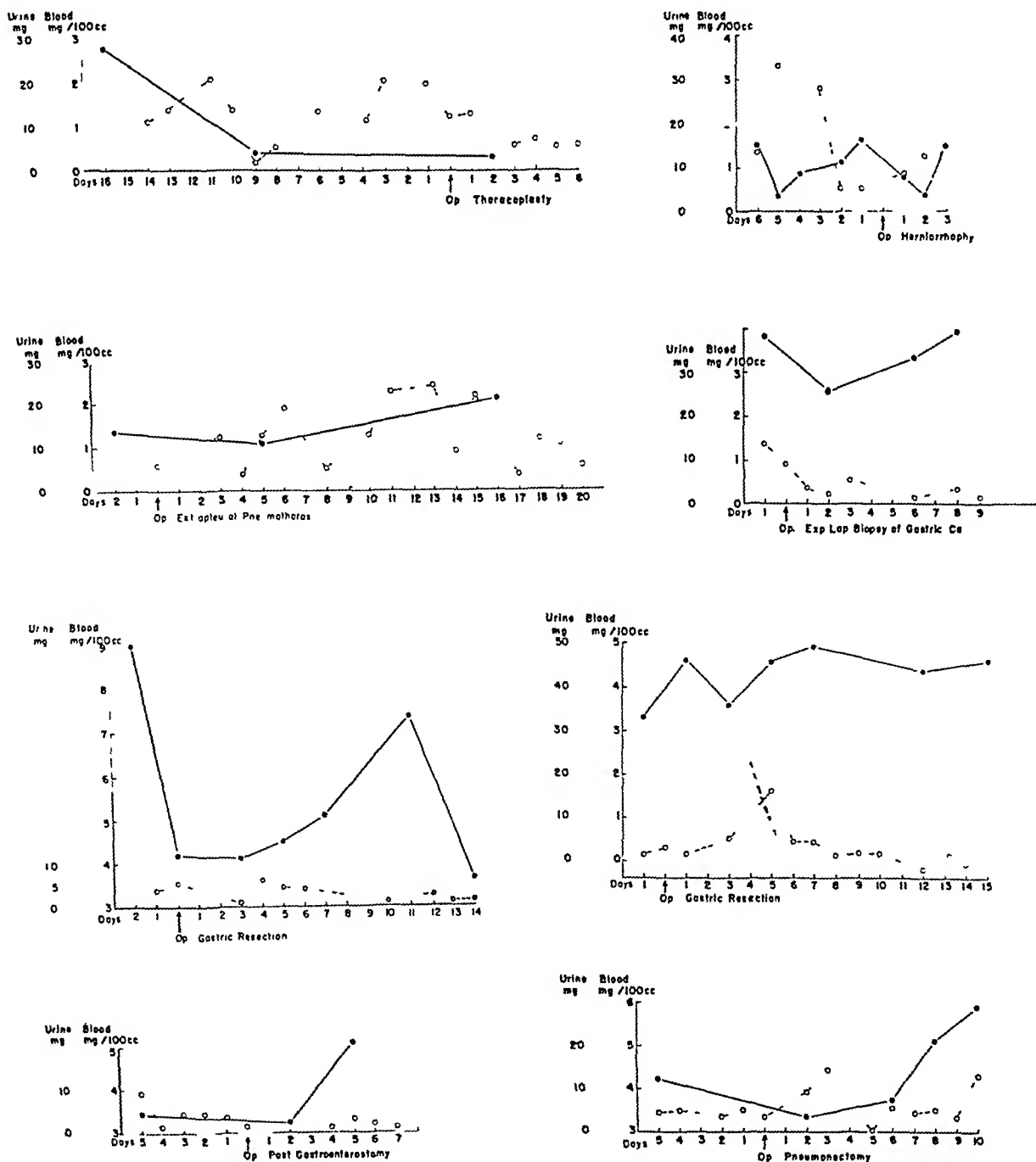


CHART 2—The blood level and the daily urinary excretion of vitamin C, before and after operation were studied on eight patients and the results are shown above. The solid line represents the blood plasma vitamin C in mg. per 100 cc., and the broken line shows the urinary excretion of ascorbic acid in mg. per 24 hours. No increase in excretion following operation was noted. The two patients who had thoracic operations, both of whom were suffering from pulmonary tuberculosis, seem to excrete an amount of vitamin C which is much larger than one would expect, considering their relatively low blood levels.

In an attempt to obtain further information which might have some bearing on the metabolism of ascorbic acid during the postoperative period, we decided to study the response of the blood level and urinary excretion of vitamin C after the intravenous administration of test doses of 1,000 mg. of crystalline

levitamic acid dissolved in 20 cc of normal saline, before and after operation. What might be called a vitamin C clearance curve was obtained by determining the fasting plasma level and the apparent rate of removal as indicated by values obtained at intervals after a standard amount of vitamin had been administered intravenously. Such studies were carried out on 14 patients.

In selecting these cases, we have chosen patients who had noninfectious lesions and who were afebrile. They were all candidates for major surgical procedures, although some of them proved to have inoperable malignancy and had only a simple exploratory celiotomy or exploration and colostomy. The ages, diagnoses, type of operation and anesthesia are shown in Table II.

TABLE II

Case No	Age	Diagnosis	Operation	Anesthesia
1	33	Duodenal ulcer	Excision of ulcer Posterior gastro-enterostomy	Ether
2	23	Duodenal ulcer	Posterior gastro-enterostomy	Ether
3	20	Duodenal ulcer	Pólya resection	Ether
4	30	Duodenal ulcer	Pólya resection	Spinal
5	53	Ca stomach	Pólya resection	Ether
6	55	Ca stomach	Exclusion and Pólya anastomosis	Spinal
7	59	Ca stomach	Exploration Biopsy	Ether
8	58	Ca stomach	Pólya resection	Ether
9	66	Ca rectum	Loop colostomy	Ether
10	45	Ca rectum	Loop colostomy	Ether
11	60	Ca rectum	(1) Groin dissection (2) Abdominoperineal resection	Ether
12	64	Ca rectum	Abdominoperineal resection	Spinal and ether
13	68	Ca sigmoid	Resection	Ether
14	43	Exophthalmic goiter	Hemithyroidectomy	Nitrous oxide

The preoperative blood clearance curves which we obtained are similar to those of Wright and his coworkers¹² and to those of Sloan,¹¹ and show the same variation in contour, depending to some extent on the degree of vitamin C depletion of the individual as shown by the fasting blood level. The curves on our 14 patients, together with three normal controls, are shown in Chart 3.

Sloan's work is particularly interesting, because the order of magnitude of his determinations, made 15 minutes after the test dose, is the same as those obtained by Wright and by ourselves. He made, in addition, some determinations, at shorter intervals after the initial dose, which indicate that the blood level immediately after injection is much higher, reaching 27.4 mg per cent in one case. This is significant because it indicates that at the 15-minute interval the blood level is falling so rapidly that any slight delay in obtaining this blood sample might be enough to allow the blood level to change somewhat. We feel that this must be kept in mind in interpreting the 15-minute values. At the end of one hour the curve has flattened out sufficiently to make the time factor less important.

VITAMIN C IN SURGICAL PATIENTS

When an intravenous dose of 1,000 mg of cevitamic acid is given on several days in close succession, the fasting plasma level tends to rise, as would be expected. Simultaneously the peak of the curve becomes higher and its rate of fall slower. The tendency is toward the pattern of the curves shown by the normal controls.

The clearance curves obtained after operation show, in some cases, a marked change in contour. In other cases the change was less marked and in some, entirely absent. When present, these changes appeared usually on the second or third postoperative day and persisted for several days, sometimes as long as a week. The change in contour consists in a lowering of the peak

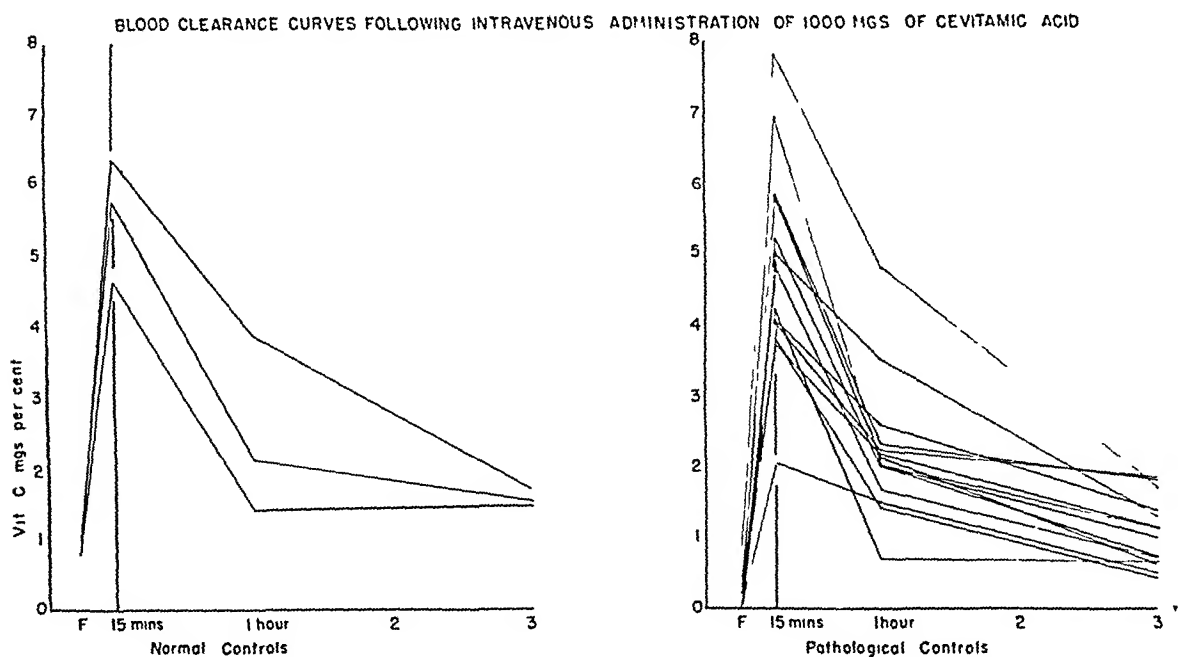


CHART 3.—Blood clearance curves were obtained by giving 1,000 mg of cevitamic acid dissolved in 20 cc of normal saline intravenously. The blood plasma vitamin C was determined before and at intervals of 15 minutes, one, two and three hours after administration. The curves obtained on three normal controls are shown at the left, and those on the 14 patients studied appear on the right. The disease conditions from which these patients were suffering are shown in Table II.

to which the blood level rises immediately after the injection of vitamin C and a more rapid fall toward the starting level. The whole curve becomes flattened and tends to lose the characteristic shape of the control curves.

All the data on these patients appear in the protocols appended to each case report, and no attempt has been made to show graphically all the curves obtained. Only typical curves, before and after operation, are given to illustrate the variations which occur. Thus, Chart 4 shows the curves on Case 2, and Chart 7 those on Case 11, both of whom show a marked change in the contour of their postoperative curves. Case 4, whose curves appear in Chart 5, showed only moderate postoperative curve changes, while no change at all is found in the curves following operation in Case 10, as shown in Chart 6.

ABBREVIATED CASE REPORTS AND PROTOCOLS

Case 1—A male, age 33, was admitted to the hospital, following a massive hemorrhage from a duodenal ulcer. On admission, his red blood cell count was 1,800,000 and

hemoglobin 40 per cent His preoperative blood cevitic acid was low on two determinations (0.14 and 0.07 mg per cent) The bleeding failed to stop, and an excision of the bleeding duodenal ulcer and posterior gastro-enterostomy were performed under nitrous oxide and ether anesthesia

Protocol Case 1

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
1/8/38	Fasting	0.14	7.8	
1/9/38			21.5	
1/10/38	Fasting	0.07		1,000 I V
Clearance curve	15 mins	5.21		
	1 hr	2.04	72.9	
	3 hrs	0.78		
	5 hrs	0.67	211.9	
	7 hrs	0.61		
	7-24 hrs		6.8	
1/11/38	Fasting	0.27	9.5	
1/12/38	Fasting	0.07	14.9	
1/13/38	Fasting	0.49	11.2	
1/14/38	Fasting	0.34		Operation
1/15/38	Fasting	0.24		
1/16/38			358.2	1,000 I V
1/17/38	Fasting	0.52		1,000 I V
Clearance curve	15 mins	1.81		
	1 hr	1.09		
	3 hrs	0.97	194.3	
	5 hrs	0.89		
	7 hrs	0.83	27.4	
	7-24 hrs		64.0	
1/18/38	Fasting	0.55	664.1	1,000 I V
1/19/38	Fasting	0.78		1,000 I V
1/20/38			342.5	
1/21/38	Fasting	0.74	913.7	1,000 I V
1/22/38	Fasting	0.79		1,000 I V
1/23/38				1,000 I V
1/24/38	Fasting	0.97	570.3	1,000 I V
1/25/38	Fasting	1.06	49.8	1,000 I V
1/26/38	Fasting	1.01	315.9	1,000 I V
1/27/38	Fasting	1.02		1,000 I V
Clearance curve	15 mins	6.69		
	1 hr	3.83		
	3 hrs	1.42		
	5 hrs	1.13	239.4	
	7 hrs	1.07	5.7	
	7-24 hrs		6.7	
1/28/38	Fasting	0.68		

The preoperative clearance curve is normal in contour, with a peak rising to 5.21 mg per cent. The curve on the third day after operation is markedly flattened, rising to 1.81 mg per cent. No further curves were done until 13 days after operation. During this time he had received 11 doses of 1,000 mg of cevitic acid intravenously. The fasting blood level rose to 1.02 mg per cent, and the curve regained its normal contour.

It is interesting to note that the amount of cevitamic acid excreted in the urine after the administration of 1,000 mg of cevitamic acid intravenously was only slightly greater on the second day after operation and slightly lower on the third postoperative day, than the preoperative output had been, although the fasting blood level was higher after operation due to the vitamin C administered

Case 2—A male, age 23, was admitted to the hospital, for an obstructing duodenal ulcer His physical condition was good except for a recent loss of five pounds in weight Blood examination showed a red blood cell count of 4,350,000 with a hemoglobin of 80 per cent His blood cevitamic acid level was low (0.07 mg per cent), and the pre-operative clearance curve was normal A posterior gastro-enterostomy was performed under nitrous oxide-ether anesthesia

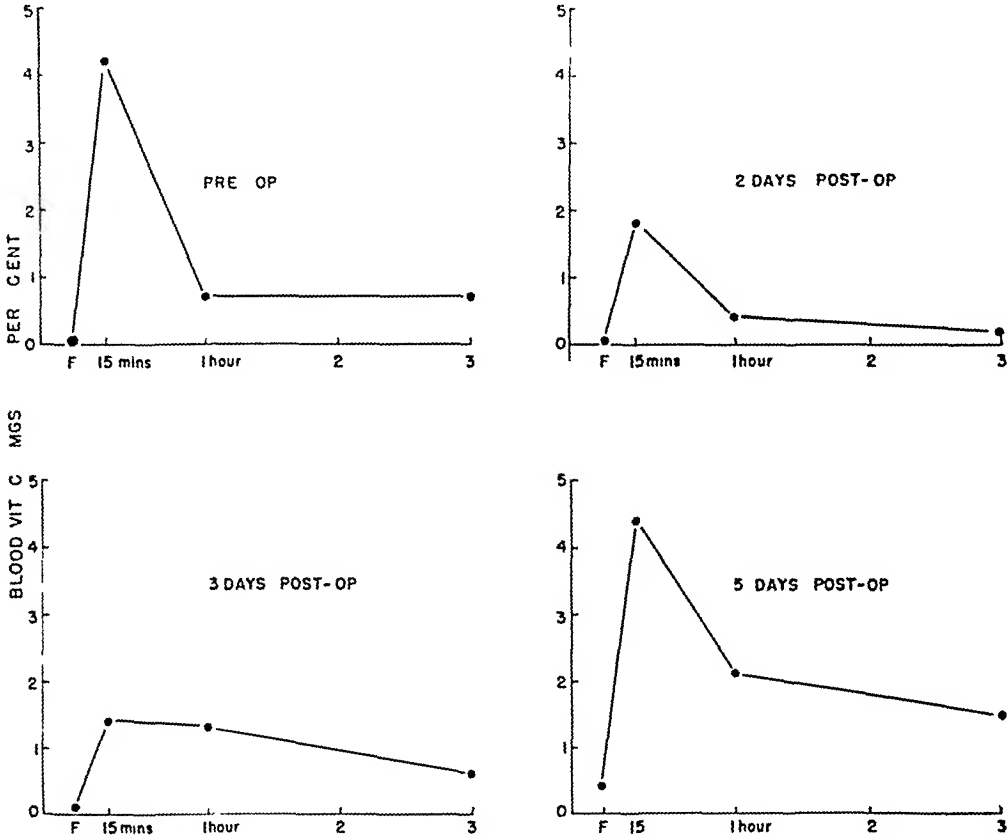


CHART 4—Case 2 The vitamin C clearance curves before operation and on the second third and fifth postoperative days are shown A marked change in contour occurs on the second and third postoperative day, but on the fifth day after operation the curve has returned essentially to normal

During the first 12 days after operation, ten doses of 1,000 mg of vitamin C were given intravenously The curves on the second and third days after operation show marked flattening, while that on the fifth day has returned essentially to normal (Chart 4)

The fasting blood level rises after operation in response to the administration of vitamin C, but the urinary output of cevitamic acid following the intravenous administration of 1,000 mg of cevitamic acid shows only a slight increase after operation over the amount excreted preoperatively

Protocol Case 2

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
1/15/38	Fasting	0.07		
1/16/38			28.4	
1/17/38			26.9	
1/18/38				1,000 I V

Protocol Case 2 (Continued)

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
	Clearance curve { 15 mins	4 23		
	1 hr	0 71		
	3 hrs	0 68	239 8	
	5 hrs	0 22	12 4	
	7 hrs	0 18	19 5	
1/19/38	Fasting	0 18	3 2	
1/20/38	Fasting	0 07	12 7	
1/21/38			20 4	
1/22/38				
1/23/38				
1/24/38	Fasting	0 07	15 7	
1/25/38			20 8	
1/26/38			20 3	
1/27/38			10 8	
1/28/38			8 7	
1/29/38				
1/30/38			3 1	
1/31/38	Fasting	0 02	11 5	
2/ 1/38			23 0	
2/ 2/38			10 9	Operation
2/ 3/38	Fasting	0 02	9 7	
2/ 4/38	Fasting	0 07		1,000 I V
	Clearance curve { 15 mins	1 79		
	1 hr	0 37		
	3 hrs	0 21	74 1	
	Fasting	0 11		1,000 I V
2/ 5/38				
	Clearance curve { 15 mins	1 42		
	1 hr	1 29		
	3 hrs	0 61		
2/ 6/38			447 1	
2/ 7/38	Fasting	0 35		1,000 I V
	Clearance curve { 15 mins	4 40		
	1 hr	2 10		
	3 hrs	1 47	161 8	
	3-24 hrs		265 1	
2/ 8/38	Fasting	0 64	320 6	1,000 I V
2/ 9/38	Fasting	0 61	28 2	1,000 I V
2/10/38	Fasting	0 44		1,000 I V
	Clearance curve { 15 mins	5 07		
	1 hr	1 42	208 7	
	3 hrs	1 45	31 6	
2/11/38	Fasting	0 54		1,000 I V
2/12/38				1,000 I V
2/13/38			34 7	1,000 I V
2/14/38			2 3	1,000 I V
2/15/38			5 3	

Case 3 —A male, age 20, was admitted to the hospital, because of a duodenal ulcer which could not be controlled on a medical regimen. He was in excellent general condition, had lost no weight, and showed a red blood cell count of 4,890,000 with a hemoglobin of 90 per cent. His initial blood cevitamic acid level was low (0.12 mg per cent).

A subtotal gastrectomy and posterior Polya anastomosis were performed under

VITAMIN C IN SURGICAL PATIENTS

nitrous oxide-ether anesthesia He received 1000 mg of cevitamic acid intravenously each day for four days before and for four days after operation His fasting blood level was 0.54 mg per cent on the morning of operation

The clearance curve on the day after operation shows marked flattening but on the third day a normal curve was obtained The extent and duration of the post-operative changes are much less than in Case 2, who was also a young man in good physical condition, but who had an even lower initial cevitamic acid level, and received no preoperative medication with vitamin C These changes are also less marked than in Case 13, who had a similar initial blood level and received preoperative vitamin C, but who was older and in poorer general physical condition

There is some increase in the amount of vitamin C excreted in the urine following the intravenous administration of 1,000 mg of cevitamic acid during the postoperative interval This is not more than can be attributed to the higher fasting blood level

Date		Time		Protocol Case 3		Urine Vit C Mg	Dosage Mg
				Blood Vit C Mg Per Cent			
2/24/38		Fasting		0 12		69 8	
		Clearance curve	15 mins	5 82		148 3	
			1 hr	2 02		9 5	
			3 hrs	1 02			
			3-24 hrs				1,000 I V
2/25/38		Fasting		0 54			1,000 I V
2/26/38		Fasting		0 25		13 9	1,000 I V
2/27/38		Clearance curve	15 mins	2 86		10 6	1,000 I V
2/28/38			1 hr	1 01			Operation
3/ 1/38			3 hrs	0 53			1,000 I V
			3-24 hrs				
3/ 2/38		Fasting		0 41		104 6	
3/ 3/38		Fasting		0 66		7 0	
		Clearance curve	15 mins	7 51		516 5	
			1 hr	1 78			1,000 I V
			3 hrs	0 98			1,000 I V
			3-24 hrs				
3/ 4/38		Fasting		0 69		313 1	
3/ 5/38		Fasting		0 80		149 1	
3/ 6/38						339 6	
3/ 7/38							1,000 I V
3/ 8/38							
3/ 9/38							
3/10/38							
3/11/38							
		Fasting		0 84		289 2	
		Fasting		0 73		54 5	
		Clearance curve	15 mins	4 95			
			1 hr	1 83			
			3 hrs	1 32			
			3-24 hrs				1,000 I V

Case 4 —A male, age 30, was admitted to the hospital, who was in good physical condition, notwithstanding that he was suffering from a partial pyloric obstruction resulting from a duodenal ulcer There was no history of weight loss His red blood

cell count was 5,000,000 and hemoglobin 90 per cent He had an initial blood cevitic acid level of 0.29 mg per cent

The first clearance curve was done while he was receiving 3,000 to 4,000 cc of parenteral fluid daily Following this, a jejunostomy was performed for feeding, and parenteral fluid was discontinued Ten days later, another clearance curve was done It is almost identical with the first one and we believe is strong evidence against the influence of even large amounts of parenteral fluid on these curves

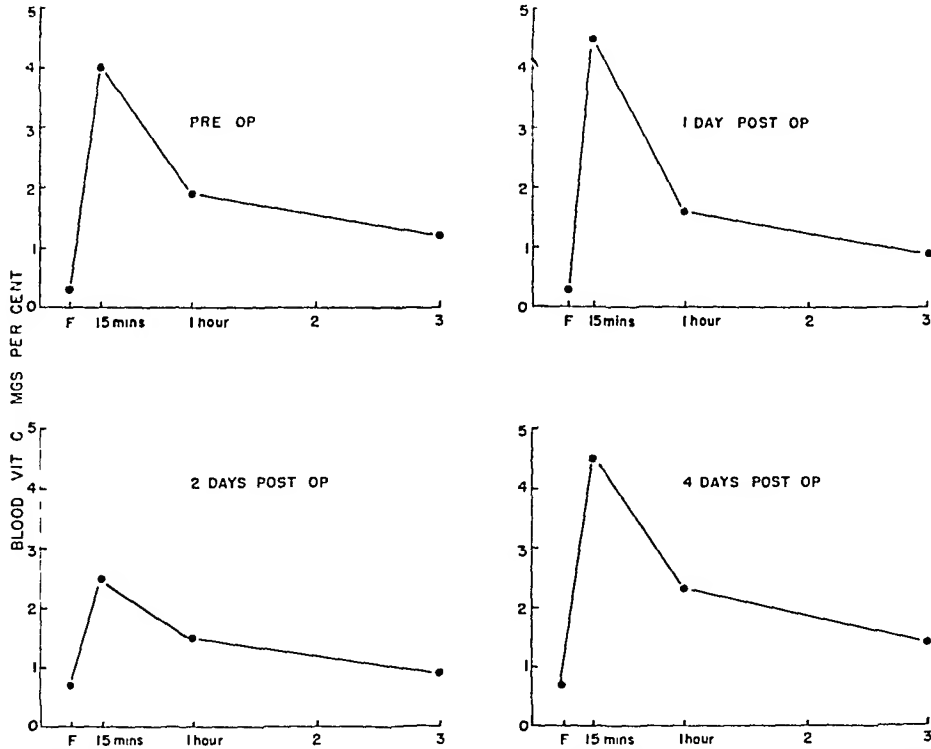


CHART 5—Case 4. Vitamin C clearance curves were obtained on this patient before operation and on the first, second and fourth postoperative days. A change in contour of the curve is seen, only, in the one obtained on the second day after operation

At operation, a subtotal gastrectomy with a posterior Polya anastomosis was performed The clearance curve on the first day after operation shows no change On the second day the curve is definitely flattened, but it has resumed its normal contour on the fourth day (Chart 5)

There is no significant increase in the amount of vitamin C excreted in the urine after the intravenous administration of 1,000 mg of cevitic acid after operation

Protocol Case 4

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
4/22/38	Fasting	0.29		1,000 I V
Clearance curve	15 mins	4.21		
	1 hr	2.01	114.0	
	3 hrs	1.16		
	3-24 hrs		88.1	
4/23/38	Fasting	0.47		
4/24/38			7.4	
4/25/38			28.2	
4/26/38				Operation (I)
4/27/38				

VITAMIN C IN SURGICAL PATIENTS

Protocol Case 4 (Continued)

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
4/28/38				
4/29/38				
4/30/38				
5/ 1/38				
5/ 2/38				
5/ 3/38				
5/ 4/38				
5/ 5/38				
5/ 6/38				
	Fasting			
Clearance	15 mins	0 26		
curve	1 hr	3 95		
	3 hrs	1 86		
	3-24 hrs	1 18		1,000 I V
5/ 7/38				
5/ 8/38				
5/ 9/38			255 9	
5/10/38				
5/11/38				
	Fasting			
Clearance	15 mins	0 25		
curve	1 hr	4 54	2 5	
	3 hrs	1 64		Operation (2)
5/12/38				1,000 I V
	Fasting			
Clearance	15 mins	0 87	60 7	
curve	1 hr	0 70		
	3 hrs	2 54		
	3-24 hrs	1 47		1,000 I V
5/13/38		0 85		
5/14/38			198 2	
	Fasting		2 9	
Clearance	15 mins	0 66	52 7	
curve	1 hr	4 54		
	3 hrs	2 28		1,000 I V
		1 38		
			213 7	

Case 5—A male, age 53, was admitted to the hospital, in fair general condition, except for a recent weight loss of 25 pounds. Roentgenologic examination showed a large, ulcerated lesion on the lesser curvature of the stomach. His red blood cell count was 4,250,000, and hemoglobin 75 per cent. His fasting blood cevitic acid was low (0.14 and 0.10 mg per cent), and the preoperative curve was normal in shape. At operation, a subtotal gastric resection for a carcinoma of the stomach was performed, under nitrous oxide-ether anesthesia. The clearance curve on the fourth day after operation shows the typical flattening and rose only to 1.05 mg per cent. Following this he received 200 mg of cevitic acid intravenously for 13 days, with a considerable rise in the fasting blood level. A curve done 18 days after operation shows a normal result.

The amount of cevitic acid recovered from the urine, after the administration of 1,000 mg intravenously, was less on the fifth postoperative day than before operation.

Protocol Case 5

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
1/12/38	Fasting	0 14		
1/13/38	Fasting	0 10	12 0	
		13		1,000 I V

Protocol Case 5 (Continued)

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
Clearance curve	15 mins	4 90		
	1 hr	1 71		
	3 hrs	0 78		
	5 hrs	0 73	87 3	
	7 hrs	0 33		
	7-24 hrs		72 5	
1/14/38	Fasting	0 17	12 4	
1/15/38	Fasting	0 27		
1/16/38				
1/17/38	Fasting	0 11		
1/18/38	Fasting	0 15		
1/19/38	Fasting	0 03	37 8	
1/20/38			16 4	
1/21/38				
1/22/38	Fasting	0 15		
1/23/38				
1/24/38	Fasting	0 17		Operation
1/25/38	Fasting	0 11	12 4	
1/26/38	Fasting	0 11	19 0	
1/27/38	Fasting	0 07	19 4	
1/28/38	Fasting	0 11		1,000 I V
Clearance curve	15 mins	1 05		
	1 hr	0 35		
	3 hrs	0 17	69 3	
	5 hrs	0 04		
	7 hrs	0 07	28 0	
	7-24 hrs		20 0	
1/29/38	Fasting	0 07		200 I V
1/30/38			3 1	200 I V
1/31/38	Fasting	0 04	25 0	200 I V
2/ 1/38	Fasting	0 31	35 6	200 I V
2/ 2/38	Fasting	0 35	26 2	200 I V
2/ 3/38	Fasting	0 51	15 5	200 I V
2/ 4/38	Fasting	0 48	49 1	200 I V
2/ 5/38	Fasting	0 73		200 I V
2/ 6/38			77 4	200 I V
2/ 7/38	Fasting	0 75	75 8	200 I V
2/ 8/38	Fasting	0 52	13 5	200 I V
2/ 9/38	Fasting	0 70	97 6	200 I V
2/10/38	Fasting	0 69	97 9	200 I V
2/11/38	Fasting	0 63		1,000 I V
Clearance curve	15 mins	8 69		
	1 hr	5 08		
	3 hrs	1 60		
	5 hrs	1 33		
	7 hrs	1 09		
2/12/38	Fasting	0 61		

Case 6—A male, age 55, entered the hospital, with a roentgenologic diagnosis of carcinoma of the stomach. He was in good general condition except for a moderate secondary anemia. His red blood cell count was 3,640,000 and hemoglobin 60 per cent. He had an initial blood cevitic acid level of 0.40 mg per cent. At operation, per-

VITAMIN C IN SURGICAL PATIENTS

formed under spinal anesthesia, the growth was found to be inoperable and an exclusion operation with a Pólya anastomosis was performed. Following operation he received 1,000 mg of crystalline cevitamic acid daily.

The curve on the first day after operation shows definite flattening and the one on the third postoperative day shows some. These changes are less marked than in Case 13, which we believe to be due to his better general condition and higher initial cevitamic acid level. His behavior is very similar to that of Case 3.

Protocol Case 6

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
2/24/38	Fasting	0 40		1,000 I V
	Clearance curve { 15 mins	4 04		
	{ 1 hr	2 29		
	{ 3 hrs	1 88		
	3-24 hrs		4 1	
2/25/38			10 8	
2/26/38				
2/27/38			19 5	
2/28/38			9 9	1,000 I V
3/ 1/38				Operation
3/ 2/38	Fasting	0 24		1,000 I V
	Clearance curve { 15 mins	2 84		
	{ 1 hr	1 58		
	{ 3 hrs	0 68		
	3-24 hrs		604 7	
3/ 3/38	Fasting	0 57	411 8	1,000 I V
3/ 4/38	Fasting	0 78		1,000 I V
	Clearance curve { 15 mins	3 86		
	{ 1 hr	1 87		
	{ 3 hrs	1 51	74 9	
	3-24 hrs		269 7	
3/ 5/38	Fasting	0 72		1,000 I V
3/ 6/38				
3/ 7/38				
3/ 8/38			100 1	1,000 I V
3/ 9/38			45 8	
3/10/38	Fasting	0 55	18 3	
3/11/38			12 1	

Case 7—A male, age 59, entered the hospital, with a roentgenologic diagnosis of extensive carcinoma of the stomach. He was in fair general condition. His blood showed a red blood cell count of 3,550,000 with a hemoglobin of 50 per cent. He stated that he had lost ten pounds during the past year. He had an initial blood cevitamic acid of 0.07 mg per cent.

Operation consisted of an exploratory celiotomy and biopsy of an inoperable gastric neoplasm. During the first six days after operation four doses of 1,000 mg of cevitamic acid were given intravenously. The clearance curve on the first day after operation was essentially unchanged. On the third day the curve is flattened, but on the fourth day it had returned to its normal shape.

The amount of vitamin C excreted in the urine after the intravenous administration of 1,000 mg of cevitamic acid does not become greater than the excretion before operation until the fourth postoperative day, and corresponds with a considerable rise in the fasting blood level.

Protocol Case 7

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
4/28/38	Fasting	0 07		1,000 I V
Clearance curve	15 mins	2 07		
	1 hr	1 53		
	3 hrs	0 45	38 0	
	3-24 hrs		3 4	
4/29/38				Operation
4/30/38	Fasting	0 15		1,000 I V
Clearance curve	15 mins	3 58		
	1 hr	1 91		
	3 hrs	1 03	5 3	
	3-24 hrs		37 8	
5/ 1/38			17 9	
5/ 2/38	Fasting	0 19		1,000 I V
Clearance curve	15 mins	1 50		
	1 hr	1 27	8 9	
	3 hrs	0 74	15 6	
	3-24 hrs		31 8	
5/ 3/38	Fasting	0 37		1,000 I V
Clearance curve	15 mins	3 65		
	1 hr	1 66	25 7	
	3 hrs	1 10		
	3-24 hrs		449 4	
5/ 4/38			22 5	
5/ 5/38	Fasting	0 66		1,000 I V
Clearance curve	15 mins	3 07		
	1 hr	1 89	48 6	
	3 hrs	1 23	123 8	
	3-24 hrs		185 3	
5/ 6/38			12 7	

Case 8—A male, age 58, entered the hospital, with a roentgenologic diagnosis of carcinoma of the stomach. He was in good general condition except for a secondary anemia of moderate degree. His red blood cell count was 3,490,000 and hemoglobin 50 per cent. There was no history of recent weight loss. His initial blood cevitic acid level was 0.47 mg per cent.

At operation, a subtotal resection of the stomach with a posterior Polya anastomosis was performed. There is flattening of the clearance curves on the second and third days after operation, although the latter is tending to resume a normal contour. The duration of the changes in the clearance curves is less here than in similar patients whose vitamin C depletion is more marked (Cases 2 and 5).

On the second day after operation less vitamin C was excreted in response to the intravenous administration of 1,000 mg of cevitic acid than before operation.

Protocol Case 8

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
6/18/38	Fasting	0 47		1,000 I V
Clearance curve	15 mins	5 84		
	1 hr	2 38		
	3 hrs	1 85	368 0	
6/19/38				

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Protocol Case 8 (Continued)

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
6/20/38			4 0	Operation
6/21/38				
6/22/38	Fasting	0 24		1,000 I V
	Clearance curve { 15 mins	2 38		
	{ 1 hr	1 52		
	{ 3 hrs	0 51		
	3-24 hrs		288 4	
6/23/38	Fasting	0 41		1,000 I V
	Clearance curve { 15 mins	4 73		
	{ 1 hr	1 85		
	{ 3 hrs	1 13		

Case 9 —A male, age 66, had had an exploratory celiotomy and loop colostomy performed for inoperable carcinoma of the rectum. He was in good general condition except for a recent weight loss of ten to 15 pounds. Blood studies showed his red blood cell count to be 4,470,000, and the hemoglobin 75 per cent. He had an initial blood cevitamic acid level in the low normal range (0.66 and 0.87 mg per cent).

The clearance curves after operation show no flattening. In fact, the one on the second day has an exceptionally high peak.

The urinary excretion of vitamin C after the intravenous administration of 1,000 mg of cevitamic acid is somewhat greater on the second and third days after operation than preoperatively, but on the eleventh postoperative day it is less.

Protocol Case 9

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
3/15/38	Fasting	0 66	4 2	
3/16/38	Fasting	0 87		1,000 I V
	Clearance curve { 15 mins	7 80		
	{ 1 hr	4 81		
	{ 3 hrs	1 74	74 8	
	3-24 hrs		162 0	
3/17/38	Fasting	1 41	10 6	
3/18/38			3 8	
3/19/38				
3/20/38			0 9	
3/21/38				Operation
3/22/38	Fasting	0 58		1,000 I V
	Clearance curve { 15 mins	8 03		
	{ 1 hr	6 36		
	{ 3 hrs	2 45		
	3-24 hrs		31.4	
3/23/38	Fasting	0 75		1,000 I V
	Clearance curve { 15 mins	13 46		
	{ 1 hr	6 70	65 1	
	{ 3 hrs	4 64	171 3	
	3-24 hrs		195 0	
3/24/38	Fasting	1 27		1,000 I V.
	Clearance curve { 15 mins	8 68		
	{ 1 hr	5 99		
	{ 3 hrs	1 87		
	3-24 hrs		641 7	

Protocol Case 9 (Continued)

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
3/25/38			161 0	
3/26/38				
3/27/38			197 0	
3/28/38			109 8	
3/29/38			115 2	
3/30/38			34 9	
3/31/38			34 7	
4/ 1/38	Fasting	0 68		1,000 I V
	Clearance curve { 15 mins	4 02		
	{ 1 hr	3 33	295 7	
	{ 3 hrs	1 90		
	3-24 hrs			

Case 10—A male, age 45, was very similar to Case 9, except that he was younger, and had a lower initial blood level (0.34 mg per cent). His general physical condition was good. There had been no recent loss of weight. His blood showed a red blood cell count of 4,320,000 with a hemoglobin of 80 per cent. He had an exploratory celiotomy and loop colostomy for inoperable carcinoma of the rectum. There is no flattening of the clearance curves after operation (Chart 6).

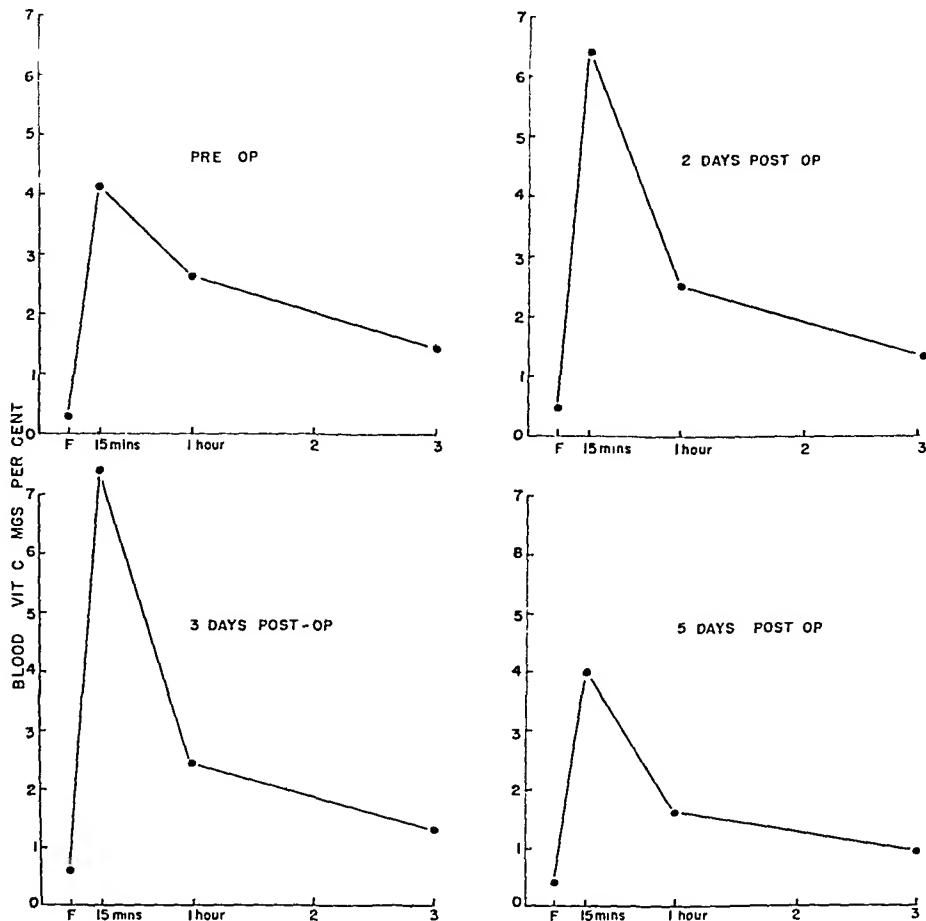


CHART 6—Case 10 Vitamin C clearance curves were obtained before operation and two, three and five days after operation. There is no flattening of the peak of the post operative curves, and, in fact, those on the second and third days after operation show a greater rise than before operation. This can be attributed in our opinion to the repeated intravenous administration of a large dose of cevitamic acid and does not occur, in our experience, when a more extensive surgical procedure is carried out.

VITAMIN C IN SURGICAL PATIENTS

Protocol Case 10

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg Operation 1,000 I V
3/26/38	Fasting	0 34		
	Clearance curve { 15 mins 1 hr 3 hrs	4 07 2 64 1 40		
3/27/38			109 1	
3/28/38	Fasting	0 47	14 7	
	Clearance curve { 15 mins 1 hr 3 hrs	6 39 2 50 1 25		1,000 I V
3/29/38	Fasting	0 57	8 4	
	Clearance curve { 15 mins 1 hr 3 hrs	7 44 2 40 1 32		1,000 I V
3/30/38	3-24 hrs			
3/31/38	Fasting	0 37	351 4	
	Clearance curve { 15 mins 1 hr 3 hrs	4 03 1 58 0 91	22 2	1,000 I V
4/ 1/38	3-24 hrs		206 7 12 6 3 9	

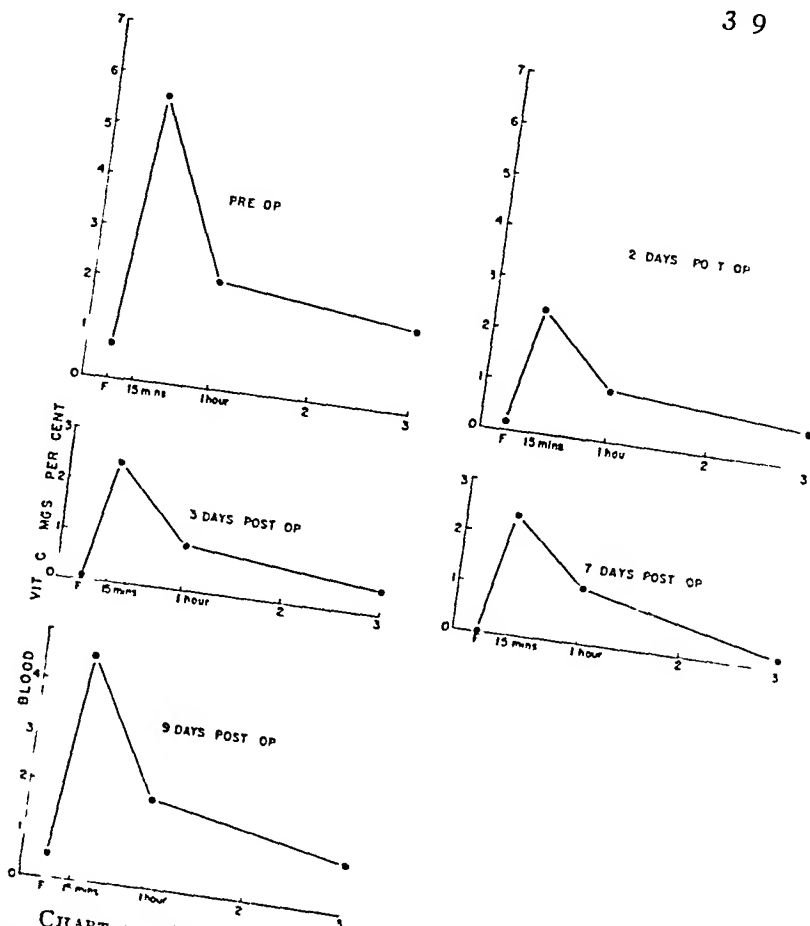


CHART 7—Case 11 The vitamin C clearance curves obtained before operation and on various postoperative days are shown. Following operation there is a marked change in contour in these curves which persists until the ninth postoperative day.

Case 11—A male, age 60, who entered the hospital because of a carcinoma of the rectum, is particularly instructive because he was subjected to two separate operative procedures, the second of much greater magnitude than the first

He was in fair general condition, but had lost ten pounds in the past year. His blood showed a red blood cell count of 4,060,000 with a hemoglobin of 90 per cent. His initial blood cevitic acid was 0.11 mg per cent. The first operation was a biopsy of a rectal growth and a unilateral groin dissection. Clearance curves done on the second and fourth days after this operation show no flattening, and their peaks rise successively higher as the fasting blood level increases.

Eleven days after the first operation, a combined abdominoperineal resection of a rectal carcinoma was carried out. Following this there is marked flattening of the clearance curve, which persists until the seventh postoperative day. On the ninth day after operation the curve has returned essentially to normal (Chart 7).

Protocol Case 11

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
5/26/38			7.1	
5/27/38	Fasting	0.11		1,000 I V
	Clearance curve { 15 mins	3.77		
	{ 1 hr	2.21	92.8	
	{ 3 hrs	1.15	48.2	
	3-24 hrs		10.8	
5/28/38				
5/29/38				
5/30/38			6.4	
5/31/38			2.8	
6/ 1/38			7.3	
6/ 2/38				Operation (1)
6/ 3/38			1.7	
6/ 4/38	Fasting	0.07		1,000 I V
	Clearance curve { 15 mins	4.90		
	{ 1 hr	2.08		
	{ 3 hrs	1.22	121.5	
6/ 5/38			44.2	
6/ 6/38	Fasting	0.55		1,000 I V
	Clearance curve { 15 mins	6.09		
	{ 1 hr	3.58		
	{ 3 hrs	1.71	126.5	
	3-24 hrs		264.7	
6/ 7/38				
6/ 8/38			7.4	
6/ 9/38			6.0	
6/10/38	Fasting	0.71		1,000 I V
	Clearance curve { 15 mins	5.63		
	{ 1 hr	2.07		
	{ 3 hrs	1.58	215.0	
6/11/38				
6/12/38				
6/13/38				Operation (2)
6/14/38				
6/15/38	Fasting	0.24		1,000 I V
	Clearance curve { 15 mins	2.42		
	{ 1 hr	1.01		
	{ 3 hrs	0.56		
6/16/38	Fasting	0.14		1,000 I V
	Clearance curve { 15 mins	2.40		
	{ 1 hr	0.92		
	{ 3 hrs	0.51		

VITAMIN C IN SURGICAL PATIENTS

Protocol Case 11 (Continued)

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
6/17/38				
6/18/38				
6/19/38				
6/20/38	Fasting	0 04		1,000 I V
	Clearance curve { 15 mins	2 40		
		1 06		
		0 21		
6/21/38				
6/22/38	Fasting	0 45		1,000 I V
	Clearance curve { 15 mins	4 46		
		1 75		
		1 02		

The increase in the amount of vitamin C excreted in the urine after operation in response to the intravenous administration of 1,000 mg of cevitamic acid is in proportion to the rise in the fasting blood level

Case 12 —A male, age 64, entered the hospital, suffering from a carcinoma of the rectum. He had lost 35 pounds during the past eight months. His red blood cell count

Protocol Case 12

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
6/ 9/38	Fasting	0 07		1,000 I V
	Clearance curve { 15 mins	6 93		
		2 19		
		0 66	175 6	
6/10/38	3-24 hrs		40 4	
6/11/38				Operation
6/12/38				
6/13/38	Fasting	0 04		1,000 I V
	Clearance curve { 15 mins	1 76		
		1 48		
		0 56		
6/14/38	Fasting	0 04		1,000 I V
	Clearance curve { 15 mins	1 74		
		1 40		
		0 90		
6/15/38				
6/16/38				
6/17/38				
6/18/38				
6/19/38				
6/20/38				
6/21/38				
6/22/38				
6/23/38				
6/24/38				
6/25/38				
6/26/38				
6/27/38	Fasting	0 17		1,000 I V
	Clearance curve { 15 mins	3 76		
		1 90		
		0 98		

was 3,300,000 and hemoglobin 80 per cent. His initial blood cevitic acid was 0.07 mg per cent.

The clearance curves on the second and third days after an abdominoperineal resection of the rectum show typical flattening. He had a very stormy convalescence and was considered too ill for further studies.

A final curve was done on the sixteenth day after operation and shows a fairly normal contour, although the peak is somewhat lower than the original preoperative curve.

Case 13—A male, age 68, entered the hospital, for resection of the sigmoid for carcinoma. He was in fairly good general condition except for a weight loss of 15 pounds. His red blood cell count was 4,400,000 and hemoglobin 80 per cent.

His initial level of blood cevitic acid was 0.14 mg per cent, and the first clearance curve is normal for this starting level. He then received ten intravenous doses of 1,000 mg of cevitic acid each. This brought his fasting blood level up into the normal range and a second clearance curve showed a somewhat higher peak than the first one.

After operation, which was a resection of the sigmoid, under nitrous oxide-ether anesthesia, the curves on the second and fourth days are flattened, while that on the sixth day after operation has regained its normal contour.

The marked drop in the fasting blood level as well as the flattening of the peaks of the clearance curves, in spite of the daily administration of large intravenous doses of Vitamin C, both before and after operation, make this case of particular interest.

There is no marked increase in the excretion of vitamin C following the intravenous administration of 1,000 mg of cevitic acid after operation. The excretion increases gradually as the fasting blood level rises.

Protocol Case 13

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
2/9/38	Fasting	0.14		1,000 I V
Clearance curve	15 mins	3.83		
	1 hr	1.44		
	3 hrs	0.51	131.0	
	3-24 hrs		10.8	
2/10/38	Fasting	0.04	6.3	1,000 I V
2/11/38			223.5	1,000 I V
2/12/38				1,000 I V
2/13/38			508.4	1,000 I V
2/14/38	Fasting	0.97		1,000 I V
2/15/38			5.0	1,000 I V
2/16/38			283.5	1,000 I V
2/17/38			33.4	1,000 I V
2/18/38	Fasting	0.77		1,000 I V
Clearance curve	15 mins	4.58		
	1 hr	2.67		
	3 hrs	1.65	203.8	
	3-24 hrs		8.2	
2/19/38				Operation
2/20/38			9.0	1,000 I V
2/21/38	Fasting	0.36		1,000 I V
Clearance curve	15 mins	2.84		
	1 hr	1.78		
	3 hrs	0.88	237.1	
			100.8	1,000 I V
2/22/38				1,000 I V
2/23/38	Fasting	0.08		
Clearance curve	15 mins	1.71		
	1 hr	1.14	254.1	
	3 hrs	0.55		

VITAMIN C IN SURGICAL PATIENTS

Protocol Case 13 (Continued)

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
2/24/38	Fasting	0 29	279 5	1,000 I V
2/25/38	Fasting	0 32		1,000 I V
Clearance curve	15 mins	4 73		
	1 hr	1 91		
	3 hrs	1 04	231 9	
	3-24 hrs		90 0	
2/26/38				1,000 I V
2/27/38			489 0	1,000 I V
2/28/38			160 9	1,000 I V
3/ 1/38			53 4	
3/ 2/38	Fasting	0 44	604 8	1,000 I V
3/ 3/38			133 3	
3/ 4/38			22 6	
3/ 5/38				
3/ 6/38				
3/ 7/38				
3/ 8/38	Fasting	0 26	26 5	
3/ 9/38			10 4	
3/10/38	Fasting	0 31		

Case 14—This case is interesting because she was a woman, age 43, with exophthalmic goiter, who had been carried on iodine for two years. During this time her basal metabolic rate had gradually risen from about +20 to +50, and she was finally admitted to the hospital for thyroidectomy. She had lost 20 pounds during the past year. Her blood examination showed a red blood cell count of 3,583,000 and a hemoglobin of 70 per cent. Her initial blood cevitamic acid was 0.29 mg per cent.

The clearance curve before operation is normal in contour and those after operation show no significant change.

Protocol Case 14

Date	Time	Blood Vit C Mg Per Cent	Urine Vit C Mg	Dosage Mg
5/3/38			5 8	
5/4/38	Fasting	0 29		1,000 I V
Clearance curve	15 mins	5 01		
	1 hr	3 57	10 3	
	3 hrs	1 31		
	3-24 hrs		2 2	
5/5/38				Operation
5/6/38	Fasting	0 26		1,000 I V
Clearance curve	15 mins	4 63		
	1 hr	1 62		
	3 hrs	0 95	156 6	
	3-24 hrs		11 9	
5/7/38	Fasting	0 62		1,000 I V
Clearance curve	15 mins	6 17		
	1 hr	2 33		
	3 hrs	1 16	271 7	
5/8/38			150 6	
5/9/38	Fasting	1 01		

Discussion—In attempting to interpret these changes in the behavior of vitamin C during the postoperative interval, there are a number of factors which must be considered. The general state of nutrition of the patient especially with reference to the degree of vitamin C depletion, and the effect on the plasma cevitamic acid level of partial starvation during the days immediately after operation must certainly be considered, as well as the type of anesthesia, the extent and duration of the surgical procedure and the amount of parenteral fluid administered during and after operation.

We feel that the consistent fall in the plasma vitamin C observed after operation cannot be accounted for entirely on the basis of decrease in vitamin C intake. Most of the patients on whom these observations were made (Chart 1) were allowed fluids by mouth, including fresh fruit juice, immediately after operation, so that an adequate supply of vitamin C was available throughout the postoperative interval. In addition, several of the cases showed a drop in the plasma vitamin C which is far too abrupt to be accounted for on the basis of starvation alone, even if the diet after operation contained no vitamin C.

It does not seem that the changes in contour observed in the clearance curves after operation can be attributed to a decrease in vitamin C intake. As a study of the protocols will show, a number of the patients showed higher fasting plasma vitamin C levels, due to previous administration of cevitamic acid, when the postoperative clearance curves were made, and yet the curves showed the changes in contour described. These changes appear, although the intake of vitamin C has been greater than that provided by the patient's usual diet, as shown by the rise in plasma cevitamic acid level.

We believe that we have evidence that the amount of parenteral fluid administered and the type of anesthesia are not of great importance in producing the changes in the clearance curves following operation. The first curve on Case 4 was done while this patient was receiving 3,000 to 4,000 cc of intravenous fluid daily, and the second curve after parenteral fluid had been replaced by jejunostomy feedings. Reference to the protocol on this patient will show the close similarity of these curves, which we think affords adequate proof that parenteral fluid does not play an important part in altering the pattern of the clearance curves.

Some of these patients were operated upon under spinal anesthesia and others under ether. The similarity of the changes in the postoperative clearance curves, when comparable operations were performed, as illustrated in the protocols, seems to indicate that these changes are independent of the type of anesthesia.

There is some evidence which suggests that the magnitude of the surgical procedure bears a relationship to the extent and duration of the postoperative alteration in the curves. One of our cases in particular seems to lend direct evidence on this point. Case 11 had two operations. The first was a biopsy of a rectal growth and a unilateral groin dissection. The curves before, and on the second and third days after, this operation are essentially alike and show no significant postoperative change. The second operation was an

abdominoperineal resection of the rectum, performed 11 days after the first operation. Following this operation, the tolerance curves show a marked and typical flattening (Chart 7) which persists until the curve obtained on the ninth day after operation.

The general nutritional state and especially the degree of vitamin C depletion seems to be another important factor. The three patients whose postoperative curves show no change (Cases 9, 10 and 14) were all in relatively good physical condition, and not as markedly depleted in vitamin C as some of the other cases studied (0.66 mg, 0.34 mg, and 0.29 mg per cent, respectively). They had relatively little surgery, two having exploratory celiotomies and loop colostomies for inoperable rectal growths and the third, a hemithyroidectomy for exophthalmic goiter. The results obtained in Case 7 are of interest in this regard. This man, in rather poor general condition and markedly depleted in vitamin C, had only an exploratory celiotomy and biopsy of an inoperable gastric carcinoma. The curve done on the third day after operation shows definite flattening of the type already described.

A study of the protocols of Cases 2 and 3 seems to lend further evidence as to the importance of vitamin C depletion in the changes seen in the clearance curves obtained following operation. The initial blood levels were low in both cases, Case 3 being slightly higher than Case 2. Four daily intravenous doses of 1,000 mg of cevitamic acid were given to Case 3, and his fasting blood level rose to 0.54 mg per cent on the day of operation. He was subjected to a more extensive surgical procedure than the other patient, yet his postoperative clearance curves show less marked changes than do those of Case 2.

SUMMARY—We believe that we have evidence that there is a change in the behavior of vitamin C during the postoperative period. A fall in the fasting plasma level of cevitamic acid occurs immediately after operation, with a gradual return to the preoperative level and when an intravenous dose of 1,000 mg of cevitamic acid is given, it is removed from the blood stream more rapidly than before operation.

The possible explanations for these changes would seem to be increased excretion, increased destruction in the body, utilization by the body, or storage. We have been unable to detect any increase in excretion following operation. The amount of cevitamic acid excreted in the urine following the administration of doses of 1,000 mg intravenously is usually less during the first few days after operation than it was before operation. Whether the changes in cevitamic acid metabolism represent increased destruction, utilization in the healing processes or storage in the body cannot be determined at the present time.

CONCLUSIONS

(1) Many hospital patients show a definite depletion of vitamin C. Fasting, plasma cevitamic acid determinations on 188 patients show that two-thirds of them have a level of less than 0.5 mg per 100 cc.

(2) This state of depletion is not limited to any one disease group, and is found in patients with a variety of pathologic conditions.

(3) Following operation, the fasting level of vitamin C in the blood plasma shows a consistent drop, with gradual return to the preoperative value

(4) There is no increase in the vitamin C excreted in the urine following operation, and the amount excreted in response to a dose of 1,000 mg of cevitamic acid given intravenously is not increased after operation

(5) When 1,000 mg of cevitamic acid are given intravenously and the plasma vitamin C determined at intervals of 15 minutes, one hour and three hours, a characteristic clearance curve is obtained

(6) Following operation the clearance curves may show a marked change in contour. These changes are influenced by the general nutritional state of the patient, by the degree of vitamin C depletion, and by the extent of the surgical procedure. They do not seem to be affected by the type of anesthesia employed or by the amount of parenteral fluid administered

(7) We suggest that the more rapid clearance from the fasting blood of vitamin C administered intravenously following operation is possibly dependent upon an increased need for this substance in the process of tissue repair and wound healing

REFERENCES

- ¹ Aschoff, L., and Koch, W. Scorbut. Eine Pathologisch-Anatomische Studie. Gustav Fisher, Jena, 1919
- ² Faulkner, J. M., and Taylor, F. H. L. Vitamin C and Infection. Ann Int Med, 10, 1867-1873, June, 1937
- ³ Geissendorfer, H. Excretion of Vitamin C in Surgical Diseases. Arch f Klin Chr, 189, 276-278, 1937
- ⁴ Harris, L. T., Ray, S. N., and Ward, A. The Excretion of Vitamin C in Human Urine and Its Dependence on the Dietary Intake. Biochem Jour, 27, 2011-2015, 1933
- ⁵ Ingalls, T. H., and Warren, H. A. Asymptomatic Scurvy. New England Jour Med, 217, 443-446, September, 1937
- ⁶ Lanman, T. H., and Ingalls, T. H. Vitamin C Deficiency and Wound Healing. ANNALS OF SURGERY, 105, 616-625, April, 1937
- ⁷ Menkin, V., Wolbach, S. B., and Menkin, M. F. Formation of Intercellular Substance by the Administration of Ascorbic Acid (Vitamin C) in Experimental Scorbutus. Am Jour Path, 10, 569-575, September, 1934
- ⁸ Mindlen, R. L., and Butler, A. M. The Determination of Ascorbic Acid in Plasma, a Macromethod and Micromethod. Jour Biol Chem, 122, 673-686, February, 1938
- ⁹ Pijoan, M., and Klemperer, F. Determination of Blood Ascorbic Acid. Jour Clin Invest, 16, 443-445, May, 1937
- ¹⁰ Rhinehart, J. F., Greenberg, L. D., Baker, F., Mettier, S. R., Bruckman, F., and Choy, F. Metabolism of Vitamin C in Rheumatoid Arthritis. Arch Int Med, 61, 537-551, April, 1938
- ¹¹ Sloan, R. A. A Comparison of Methods for Detecting and Grading Subclinical Scurvy. Jour Lab and Clin Med, 23, 1015-1026, July, 1938
- ¹² Wright, I. S., Lilienfeld, A., and MacLenethen, E. Determination of Vitamin C Saturation. Arch Int Med, 60, 264-271, August, 1937
- ¹³ Wolbach, S. B., and Howe, P. R. Intercellular Substances in Experimental Scorbutus. Arch Path and Lab Med, 1, 1-24, January, 1936
- ¹⁴ Wolbach, S. B. Vitamin C and the Formation of Intercellular Material. New England Jour Med, 215, 1158-1159, December, 1936

MOTOR FUNCTIONS OF THE STOMACH AFTER RESECTION

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IN RECENT years resection of the stomach has been widely accepted, not only as a method of treatment for cancer, but for gastric ulcers as well. Nevertheless, many surgeons are opposed to this operation, believing that the removal of such important parts of the stomach as the pylorus or antrum radically changes all digestive processes in the gastro-intestinal tract, and, therefore, cannot be without bad effects for the whole organism.

The great majority of surgeons who perform gastrectomy apparently pay much more attention to clinical data, or to the technic of the operation, than to the question of the postoperative functions of the gastro-intestinal tract. As a result, the question of how digestion is carried on after gastrectomy, of the manner in which the remaining part of the stomach in its motor and chemical activities (including the liver and pancreas) reacts to gastrectomy, and the problem of the influence of this operation upon the whole organism and upon its blood forming organs, is still far from being solved.

The study of this problem as a whole naturally presents an interesting task for many investigators. The present communication is restricted to an investigation of but one phase of the whole, namely, to a study of the motor functions only of the resected stomach. Nearly all authors who have studied the activity of the stomach after resection point out the considerable change which takes place in its motor functions. Not only the form and the topographic relations of the stomach are changed, but a change is also to be observed in its tone. The stomach walls become more feeble and distended (Spath, Friedemann, Kuschner, Heitel and others) and food is promptly evacuated into the intestine. The removal of the pylorus and antrum results in insufficient maceration of the food in the remaining portion of the stomach ("*restmagen*") Also, food is badly mixed together with the gastric juices, the secretion of which is rudely disturbed in consequence of the removal of the pyloric glands, as well as by the removal of the prepyloric part, the function of which is to act as "the main stimulator of the acid secretion" ("*sauer-zwacker*," of von Bergmann, "*sauerfabrik*," of Haberle).

Some authors (Neumann, Mirkin, and Moisova, Raix, Kuschnorenko and Heitel) are of the opinion that all these phenomena, especially the prompt evacuation on the part of the stomach remaining, may result quite independently of the method of the resection, *i e*, with regard to Billroth's methods I or II.

Other authors (Spath, Sauermondt, Jansen, Beiesov, Bal and others),

Submitted for publication October 13, 1938

on the contrary, have observed that the food, after a Billroth I resection, was retained in the stomach for a longer time. Bremer and Held offer the explanation, that the form of the stomach, resulting after resection by the Billroth I method, promotes, to a considerable degree, slower evacuation than the form of the stomach obtained when it has been resected by the Billroth No II method. A Billroth I leaves a gastric stump, which being connected with the duodenum is located between two fixed points—the hiatus esophagus and the duodenum—that is, it is obliquely directed from the left upper point downwards to the right. On the other hand the stump of the stomach, resulting from employment of the Billroth II method, is connected with the mobile loop of the gut, which brings its axis into a vertical position in the upright posture. The latter group of authors mentioned, believe that such a vertical position of the gastric stump favors a quicker evacuation than the oblique position resulting from the Billroth I method.

The average normal evacuation time from the resected stomach, if it is in good condition clinically, lasts 20 minutes according to the observations of Rosenblat and Balaban, but Bremer and Held, Beresov and Stern, Goetze, Raiz and others, show that there may be such a shortening of this period that the evacuation may be accomplished almost immediately. Food entering the stomach is not retained in it at all, but at once falls through the stoma of the anastomosis. There then occurs the type of evacuation which Germans term "*stunzentleerung*"

A rapid evacuation is especially dangerous, because of the likelihood of the formation of peptic ulcers in the small intestine, especially in those cases where the stomach is not widely enough resected and where, consequently, a part of the antrum remains, thus retaining the possibility of acid gastric juice secretion (Goetze). Some authors (Beresov and Stern) believe that the absence of the pylorus must be followed by momentary evacuation, and that consequently every resection of the stomach should inevitably result in this. Other investigators ascribe such a type of evacuation either to the method of the operation or to technical errors. Most observers, nevertheless, have noted rhythmic evacuation after gastrectomy, quite independent of the operative procedure employed, and following either a Billroth I or II method (Kalmanovsky, Seneque and Maix, and others).

Thus, from a review of the literature, no definite conclusion can be drawn as to which of the two main methods of gastrectomy can best provide the rhythm of the gastric evacuation. Goetze considers that there are two opposing sets of forces involved—the evacuating forces and the retaining ones. The former include the systole of the stomach and the hydrostatic pressure of the food itself, which is measured by the height of the liquid level in the stomach, measured from the exit. The opposing forces are the anastomosis and the hydrostatic pressure, the so-called "*hubhöhe*" (which is measured by the height from the lower pole of the stomach to the level of the anastomosis).

The systole of the stomach depends on the musculature of the gastric wall,

the muscular fibers of which are constantly in a state of definite contraction, *etc.*, the tone. The expansion of the stomach on the reception of food is a function of the tone. Goetze believes that filling-out of the portion of the stomach remaining after gastrectomy progresses in the same manner as the filling-out of the corresponding part in an unresected stomach. Goecke, Schuller, Seneque and Marx consider, too, that stomach tone does not suffer any change after resection, but remains the same as before. On fluoroscopy, the air-bubble is to be seen just as well as in the normal, unoperated stomach, and the contrast medium just as in a healthy stomach, smooths it out.

In addition to the tone of the resected stomach, the peristalsis plays a great part in its evacuation. Many authors think that peristalsis is not always observed after gastrectomy, and even not at once after the operation. Held observed peristalsis in a few cases and then only in the form of shallow, superficial waves. Goetze noted it only during the first two or three weeks following the operation, later on, it was absent, from which he inferred that the stoma at the anastomosis had become strictured. Fedorov, also, points out the lessening of peristalsis after gastrectomy. Seneque and Marx, owing to the absence of the antium-pyloic segment following gastrectomy, deny even the possibility of peristalsis. Among eight patients in whom peristalsis was observed, six showed stenosis of the stoma of the anastomosis, the result of a recurrent cancer. These authors also believe that whenever peristalsis is observed after gastrectomy, obstruction of the exit from the stomach should be ascribed as the reason. Desmares is of the same opinion.

Meyer-Buegdorf, and Heitel, observed that gastric peristalsis after the resection is independent of the method of operation. Contrary to their opinion, Rosenblat attributes the onset of peristalsis in the resected stomach to the operative procedure employed. Using the Billroth I method, he observed peristalsis in 78 per cent of his cases, while using the Billroth II method, it occurred in only 39.4 per cent. Hence, he concludes that it seems that the peristalsis following gastrectomy is the result of the restoration of reflex relations between the duodenum and the gastric wall.

The rôle of hydrostatic pressure, as a force assisting evacuation from the resected stomach, is chiefly emphasized by Goetze, Spath, Kelling, Mirkin and Moiosowa, and Held. The motion of the diaphragm during the act of breathing plays, too, a certain part among the forces contributing to stomach evacuation. This is especially evident from the observations of Biemer and Held upon the stomach, resected by the Billroth I method. Here the remaining portion of the stomach (*restmagen*) is strained along its lesser curvature between the hiatus esophagus and the duodenum. In consequence of this, motions of the diaphragm, by pressure, considerably assist evacuation from the stomach. But this may be observed only during the first days following operation and, even then, only just after the beginning of a meal. From five to 10 minutes later, under the influence of the food, the stomach takes on the shape of an egg, its lesser curvature becomes more relaxed and, consequently

the diaphragm, during breathing, does not produce the previous influence upon evacuation

Among forces delaying evacuation, the main force is the so-called "play of the pylorus" in the healthy, unoperated stomach. In the resected stomach, this phenomenon is replaced by the anastomosis, though Goetze believes that the latter does not possess the ability to close the entrance from the stomach. Opposed to his opinion, a group of authors consider that the muscular elements of the stomach form some kind of sphincter around the stoma of the anastomosis, which resembles the pylorus in its function. These authors observed such a sphincteric action only after resection by the Billroth I method (Spath, Rosenblat and Balaban, Hertel, Mirkin and Morosova, Wolfier, Maresch, Mayer and Schmidt)

At the Twelfth Congress of German Surgeons, Wolfier demonstrated the stomach of a patient five years after a gastrectomy performed by the Billroth I method. In the region of the anastomosis, he found a fold of mucosa having a height of 3.5 Mm, with a thickening of the muscular layer under it. Beresov and Stein ascribe special value to the modification of the Billroth I method developed by Haberer, according to which the gastric wall is sewed up to the duodenum, being tied with sutures in the shape of flounces. With this, in the region of the anastomosis, they found a thickened muscular layer, resembling somewhat a pyloric sphincter. They are of the opinion that the rhythm of evacuation practically depends upon the muscular contractions around this anastomosis. These contractions do not possess such a regular rhythm as does the pylorus, but later on the sphincter appears to acquire the same rhythm.

Experimentally, Bal, after performing a resection of the stomach by the Billroth I method, with the Haberer modification, also noted a thickening of the muscular wall in the region of the anastomosis. Finsterer, too, attaches great significance to the shape of the anastomosis, in regard to evacuation from the remaining stomach following gastrectomy. He offers his own technic for this operation, in which he makes an anastomosis with an incision in the lowest part of the stomach, while the upper part of the gastric stump, with the adjacent loop of a small bowel, he inverts into the stomach by means of the purse-string suture, thus forming a kind of valve over the anastomosis.

Some authors have observed, on fluoroscopy, not only a filling-out of the efferent loop, but the presence of the contrast medium in the afferent loop as well. Schwartz, Ogloblin, Kelling, and Schemacher consider this phenomenon as having a positive value, while Notzel and Teschendorf judge the retrograde filling of the afferent loop as a tendency of the organism to direct food along the normal unviolated channel. Beresov and Ribinsky observed, during the retrograde filling of the afferent loop, that there followed a heavy feeling and bilious eructations. Finsterer, fearing that in this case the duodenal stump might be insufficient, recommends the fixation of the afferent loop to the upper part of the gastric stump, thus forming an artificial spui. He considers that this will prevent passage of the food into the afferent loop.

MOTOR FUNCTION AFTER GASTRECTOMY

MOTOR FUNCTIONS OF THE STOMACH AFTER RESECTION

Based Upon Personal Clinical and Roentgenologic Observations

The appended observations were carried out under the supervision of Prof. L. W. Ratner, and cover a period of six years (1930-1936). Seventy-four patients were examined, who, during this period, had been subjected to gastrectomy for various conditions (Table I).

TABLE I

DISTRIBUTION ACCORDING TO DIAGNOSIS

Diagnosis	No. of Cases
Cancer of the antrum	9
Cancer of the body of the stomach	12
Ulcer of the antrum	6
Pyloric ulcer	4
Ulcer on the lesser curvature in the region of the angle	18
Ulcer on the lesser curvature above the angle	14
Duodenal ulcer	2
Peptic ulcer	8
Gunshot wound of the stomach *	1
	—
Total	74

* The patient with the gunshot wound was operated upon in Berlin 18 years ago, but for the last two years has been under our observation.

According to sex, there were 55 males and 19 females. Distribution according to age groups is given in Table II.

TABLE II

DISTRIBUTION ACCORDING TO AGE GROUPS

Age Group	No. of Patients
From 20 to 30 years	10
From 30 to 40 years	31
From 40 to 50 years	18
From 50 to 60 years	13
From 60 to 70 years	2

The greater number of patients (67) were operated upon by the Billroth II method with the Hacker-Eiselsberg modification, of the remaining seven cases, five were operated upon by the classic Billroth II method, and two cases, by the Pólya-Reichel modification of the Billroth II method. Ten subtotal resections were performed.

The routine technic employed in the operation by the Billroth II method, with the Hacker-Eiselsberg modification, was as follows*. The vessels of the

* The operation described, designated as the Billroth II method, with the Hacker-Eiselsberg modification, may be found described in "Chirurgische Operationslehre," V. Kleinschmidt. Published in 1927. Some authors ascribe the operation to Hoffmeister-Finsterer, or to Kronlein-Mikulicz.

gastriocolic and gastiohepatic omenta were tied and the stomach freed from adhesions. A clamp was then placed upon the duodenum just beyond the pylorus, and another applied 2 cm distal to it. (For the past two years, for this purpose we have used the Shulman's duodenal clamp.) The duodenum was cut between these two clamps. The gastric stump, wrapped in gauze, was turned to the left, while the duodenal stump was sewed in two layers, using a continuous catgut suture for the mucosa and a knotted silk suture for the seromuscular coat. A cut piece of omentum was sutured over the stump. A clamp was then placed upon the stomach, in the direction from the lesser to the greater curvature, in such a way that the lesser curvature was caught up as far as possible above the angle. A second clamp was applied distal to it. Between them, with a continuous suture, at a distance of from 6 to 8 cm, there was sewed up a loop of the small intestine nearest to the flexura duodenojejunalis, passing the loop through a hole in the mesentery of the transverse colon, beginning from the greater curvature. Above this suture, below the first clamp, the part of the stomach to be resected was cut out, and the sewed up loop of the small intestine was opened along its axis. Upon the gastric and intestinal mucosa there was placed a continuous catgut suture, that passed over the mucosa of the upper part of the stomach. The second line of sutures was placed upon the seromuscular coat of the stomach in its upper part, and on that of the stomach with the intestine in the region of the anastomosis. The gastric stump was sewed with separate sutures, up to the opening in the mesocolon. In four cases the operation was performed using the Petrov-Veresachinsky modification of the method.

Before operation every patient underwent the following examinations:

- (1) Gastric analysis
- (2) Fecal analysis for occult blood
- (3) General analyses of blood and urine
- (4) Fluoroscopy of the stomach, in which special attention was paid to the motor functions. The shape of the stomach, its mobility, tone, peristalsis and evacuation were studied. In later years attention was also given to the outlines of the gastric mucosa.

Postoperative observations using the same scheme of examination as before the operation were continued at intervals varying from two weeks to six years. In carrying out radioscopy, special attention was paid to the motor functions. The majority of the patients (38) were examined after operation from two to five times, giving a total of 132 radioscopic examinations of the stomach after resection (Table III).

Postoperative Complaints—Out of 74 patients, only four (with symptoms of cancer recurrence, revealed on radioscopy) felt epigastric pressure and suffered from vomiting after a meal. One of them, following an operation that had been performed in Berlin 18 years previously, suffered during the last three years from constant pains, which increased after ingestion of food and were sometimes accompanied by vomiting. The remaining 69 patients considered themselves quite healthy.

TABLE III

FREQUENCY OF RADIOSCOPIC EXAMINATION

Period of Postoperative Examinations	Number of Observations	Operated Upon for Cancer
From 2 wks to 1 mo	22	3
From 1 mo to 3 mos	23	7
From 3 mos to 6 mos	18	6
From 6 mos to 1 yr	21	9
From 1 yr to 2 yrs	21	5
From 2 yrs to 3 yrs	17	5
From 3 yrs to 4 yrs	4	1
From 4 yrs to 5 yrs	4	1
More than 5 yrs	2	1
Totals	132	38

All patients observed their diet only during first month following the operation. If, during this time, they broke the diet, they suffered from a feeling of heaviness in the epigastrium, and occasionally vomited. But as soon as they returned to their diet, all these phenomena disappeared. With time, more and more broke their dietary regimen. In four or five months following the operation, 14 out of 18 traced patients were eating freely any sort of food, and in from six to 12 months, only one of 21 patients was still dieting. Still later, none of them dieted, some of them even consuming alcoholic beverages such as vodka or beer in excess, without troublesome aftermath, with the exception of one patient who complained of a feeling of weight in the epigastrium after drinking three or four glasses of beer. Three others suffered similar epigastric pressure after an abundant meal, if it had been eaten quickly. When food was eaten slowly they suffered no distress.

The above indicates the insufficient capacity of the resected stomach, which being quickly filled, evokes the phenomenon of the so-called "small stomach." Similar phenomena were pointed out by Meyer-Buegdorf, Finsterer, Habeier and others. Kelling and Schuller draw attention to the feeling of hunger that arises soon after a meal and forces the patient to eat more often. In our series, only one patient experienced a feeling of hunger within a two-hour period after ingesting food. The others took their food three or four times a day, and experienced a feeling of hunger in from four to five hours after the meal. The amount of food they took excited little difference from that taken by a healthy person.

Biesenberged and Wieser explain complaints of the epigastric pressure after a meal, by the presence of a sinus in the gastric stump below the level of the anastomosis. They consider that in such a "*sackennmagen*," retention and the stagnation of food occur. In our cases we could observe the presence of such a sinus in six patients. In one patient, the sinus was at first insignificant in size, but gradually enlarged during filling-up with the contrast medium. None of the six above-mentioned patients experienced any disagreeable feeling after a meal, and all felt themselves quite healthy. Thus our data do not

confirm the opinion of Biesenberger and Wieser on the harmful influence of the "*sachennagen*"

Shape of the Resected Stomach—Tuluzakov and Golooshko believe that the shape of a resected stomach depends only upon the surgeon, and has nothing to do with its preoperative form. Opposed to this, Goetze considers that the resected stomach should present on radioscopy the shape of the whole stomach. In all our patients we found that the resected stomach took on the shape of a funnel, sometimes elongated, sometimes shortened. The axis of such a funnel was always directed vertically with reference to the anastomosis, either at the very apex of the funnel, or a little bit to the side of it. Seneque and Marx observed the same shape of the resected stomach by the Billroth II method.

Such a form of the resected stomach becomes easily understandable, if it is remembered that in performing the gastrectomy by the Billroth II method, when we cut off the resected part, we made, in accordance with our technic, the incision from the lesser toward the greater curvature from above the right side downwards to the left, the anastomosis being made at the lowest angle of the gastric wound. Both for cancer and for ulcer operations, we intentionally left the lesser curvature as little as possible, because our observations demonstrated that ulcers always recur upon the lesser curvature. Cancer recurrences, too, took place in the gastric stump along the lesser curvature. In addition, the form of the resected stomach is greatly influenced by the tone of gastric walls. Seneque and Marx are of the same opinion.

Volume of the Stomach—The volume of the stomach varied considerably depending upon the size of its remaining part, on the constitution of the patient, and on the lapse of time since the operation. With all other conditions equal, the longer the lapse of time since the operation, the larger the volume of the resected stomach. During the first three months following the operation, only six patients out of 45 examined, had a stomach of average size. All the others revealed small stomachs high in the subcostal region, which were but little distended after the ingestion of a full portion of the contrast medium. After a lapse of time, the volume of the stomach increased, after a year or more we found the stomach to be of small size in only nine out of 47 patients. In all the others the lower border of the stomach had attained a depth of from 3 to 4 cm. above the unresected stomach, and in one case it even reached this level. In no case did we observe the border reaching lower than the previous level. A gradual enlargement of the resected stomach manifests itself as a rule, but the sizes and lapses of time for this enlargement to be effected differ. It is not always possible to determine the exact causes upon which depend the degree and rate of distension. There is no doubt that the tone, the general condition of the patient and the food burden of the stomach are responsible. We were never interested in this question, because we noticed no connection between the size of the resected stomach and the manner of its evacuation.

Stomach Tone—As the tone of the stomach influences greatly its shape

before the operation, doubtless it cannot cease to be an influencing factor after the operation. This can be proved by the fact that where we observed a lessening tone in a considerable number of resected stomachs, these took on the shape of the elongated funnel, whereas, in those cases where the stomach was in a shape of a shorter and wider funnel, the tone was satisfactory and normal.

It might be thought that hypotonus of the stomach observed in some cases before the operation would remain the same after the gastrectomy. This is not true. Our observations have shown that lessened stomach tone gradually improves and becomes a satisfactory normal one after gastrectomy.

This chiefly concerns those cases where, before the operation, we had found an atonic or hypotonic stomach accompanied by pyloric stenosis in consequence of ulcer or cancer. By resecting the stomach and thus creating a free exit of food from it, we remove the cause that led to the gastric hypotonicity, namely, the stenosis, and give to the muscular fibers of the stomach the possibility to restore after a lapse of some time, sometimes very soon, its contractive ability.

Twenty-eight out of 45 patients, concerning whom exact radioscopic data of the stomach before the operation had been obtained, showed hypotonic or atonic stomachs. After gastrectomy, in periods of from two weeks to one month, in eight out of 16 patients still under observation, we still found an hypotonic stomach, in three months, only four out of 18 under observation still showed an hypotonic stomach, after six months, and later, we found no patient with atonic or hypotonic stomachs.

The recovery of tone by the resected stomach is well demonstrated by systematic observation of the same patient. We traced for a period from five to six years after gastrectomy, at various intervals, 22 patients who had hypotonic stomachs before operation. In seven cases the stomach was restored to normal tone in from one to three months and kept it during subsequent examinations. In six months only one case still showed an atonic stomach.

The tone of a normal or resected stomach, we determine by the manner of its contraction on the reception of the contrast medium, by the shape of the air-bubble, and by its shape as a whole. Hypotonus of the resected stomach is revealed when the first portion of the contrast medium, entering the stomach, takes on the form of a prolonged triangle, when the air-bubble becomes drawn out downwards, and when the stomach itself takes on the shape of an elongated funnel. On the other hand, in the case of a hypertonic stomach, the contrast medium while distending the stomach should be of a triangle shape, the lower end of which is near the right angle, and the air-bubble is flattened.

Peristalsis — In only three cases out of 132 fluoroscopic examinations made on 74 patients did we fail to see gastric peristalsis. In all the other cases we have usually found a shallow or weak peristalsis along the greater curvature, and often along the lesser curvature as well. We never observed a deep and

pronounced peristalsis. Peristalsis could be seen very shortly after gastrectomy. Two weeks after resection the appearance of superficial, lax peristaltic waves could be noticed after the entrance of the contrast medium, at first along the greater curvature and then, sometimes, also along the lesser curvature.

These waves could be observed also in those patients in whom, during resection, the large branches of the vagus nerve had been cut. This is quite comprehensible, if we take into consideration that basically the peristalsis is an automatic gastric function directed principally by its own autonomous nerve centers which lie in the gastric wall itself. Seneque and Marx are of the same opinion.

Based on his observations that gastric peristalsis, following operation by the Billroth I method, is more often to be observed (in seven out of nine cases), than after the operation by the Billroth II method (in 13 out of 33 cases), Rosenblatt draws the conclusion that the method of operation influences considerably the peristalsis, and that the latter is evidently the result of a restoration of the nervous reflex connection between the duodenum and the gastric wall. The presence of the peristalsis in nearly all our cases (in 71 out of 74 cases), who were operated upon by some modification of the Billroth II method, disproves his suggestion. Likewise, our observations disprove the opinion of Seneque and Marx, who deny even the possibility of peristalsis in the resected stomach because of the lack of the antro-pyloric segment.

Peristalsis in a healthy, unoperated stomach is of great importance for evacuation, because its waves force the gastric contents toward the pylorus and farther on into the duodenum, meanwhile resulting in better mixing together of the food and gastric juices. Whether the peristalsis plays the same rôle for the resected stomach is a question still unsolved. At any rate, its presence at the time of food reception in the resected stomach already indicates its participation in the process of food evacuation from the stomach. The real part which the peristalsis plays in the motor functions of the resected stomach will become clearer on further analysis of the basic processes of gastric evacuation.

Evacuation in the Resected Stomach—If Goetze's opinion is accepted, that the evacuation of any stomach is a resultant of the interplay of opposing forces, some leading to the evacuation and other retarding it, we may begin an analysis of how these forces react to bring about evacuation of the resected stomach. One of the main factors is the hydrostatic pressure of the food itself. It is greater, the higher the level of the liquid content in the stomach. From this point of view the hydrostatic pressure in the stomach after the operation by the Billroth II method is considerably higher than by that resected by the Billroth I method, because in the first case the axis of the stomach is directed vertically downwards and the anastomosis is situated at the lowest point of the gastric stump. To decrease this pressure, Goetze offered his modification of the operation. He made the anastomosis a little

higher up, thus leaving, from the lower end of a stump to the level of the anastomosis, a sinus of a certain size, thereby shaping the stomach into the form of a sack ("*sackenmagen*") Goetze worked on the theory that the evacuation of such a stomach would be considerably delayed because of the decrease of the hydrostatic pressure due to the "*hubhöhe*" (The pressure of a column of liquid from the lowest point in the stump up to the level of the anastomosis)

The tone of the resected stomach which, as we have seen above, gradually became normal in nearly all our patients, should be considered as the second factor assisting evacuation

Finally, peristalsis is of extreme importance in emptying, but it is closely bound up with stomach tone The feebler the tone, the less intensive are the peristaltic waves The stomach with a normal tone possesses active peristalsis which is the more expressed, the more resistance the food meets with in its evacuation To overcome the contraction of the pylorus during evacuation requires strong and deep peristaltic movement The feebler the resistance offered by the pylorus during evacuation, the less the force required of the peristaltic wave for overcoming the resistance Precisely such a condition obtains in the resected stomach in which there is usually observed a superficial lax, but never a deep segmenting peristalsis This possibly may be explained by the fact that the hydrostatic pressure of food together with a systole in the gastric wall, are practically sufficient in themselves to effect evacuation, and only a little additional force, expressed by a weak peristaltic movement, is required to overcome the impediment

What is this impediment to evacuation from the resected stomach, and does it exist at all? Since in a healthy, unoperated stomach there exists such an impediment (and a very strong one), in a form of the pylorus with its powerful musculature, then there arises naturally the thought of the presence of an analogous regulative apparatus in the region of the anastomosis of the resected stomach Some authors (Beierov, Bal and others) hold this opinion They found evidence of muscular pressure around the anastomosis, which, as they presume, closes the anastomosis on contracting and opens it by relaxation, thereby letting through certain portions of the contrast meal Nearly all authors, who call attention to the existence of this rhythmic evacuation in a resected stomach, made their observations only upon stomachs operated upon either by the Billroth I method, or by its Haberer's modification This fact gave to Bremer and Held the idea that there is formed some new automatic reflex which acts by contracting the muscular layers of the anastomosis and by annular compression of the bulbous duodenum They presume that the existence of such a reflex is quite possible, if there is taken into consideration

* We have never observed any considerable constriction of the anastomosis in the resected stomach, therefore, we cannot judge whether peristalsis of a segmenting type will arise analogously to that which takes place at the stenosis of the pylorus in the unoperated stomach

the presence of a definite nerve plexus in the region of the stomach angle (Keith, Orator)

Our observations do not bear out the principal theses of these authors. First of all, it is not right to assume that the rhythmic evacuation, which made them infer the formation of a "quasi-pylorus," can be observed only after resection by the Billroth I method. Among our 74 patients, in only seven cases, have we seen a continuous evacuation of the stomach, and this only during the first six months after operation. The remaining 67 patients showed rhythmic evacuation in definite lapses of time and with definite portions of various volume. Complete evacuation of the resected stomach required from 15 minutes to 1 or 1½ hours, ranging mostly from ¾ to 1 hour. As already stated, all our patients were operated upon by the Billroth II method, usually accompanying it by its Hacker-Eiselsberg modification. Thus, taking into consideration the presence of a rhythmic evacuation after the operation by the Billroth I method (according to the data of Beresov, Bal, Bremer and Held, Goetze, and others), and that gained from our own observations, one has to draw the conclusion that the rhythmic type of evacuation is common to both methods. Seneque and Marx came to the same conclusions.

Beresov and Stein consider the Billroth I method, using the Haberer modification, as the one which creates the best conditions for obtaining rhythmic evacuation from which rose the impression of the formation of a "quasi-pylorus." Experimenting on dogs, Bal examined histologically this "quasi-pylorus," or, as he calls it, the "pap-roller." This "pap-roller" shows itself to be of a different structure in the more dense central part. In some cases it was formed by intrusion of a seromuscular layer of the stomach and duodenum into the thickness of the anastomosis. In other cases it was formed from the seromuscular layer of the stomach alone. In the third group of the Bal nomenclature, in which the "pap-rollers" very closely resemble the normal pylorus structure, they differ, nevertheless, microscopically by revealing a considerable growth of scar tissue in the submucous layer. This scar tissue is located over the muscular elevation in the shape of a large strip.

At the Twelfth Congress of German Surgeons, Wolfner demonstrated the stomach of a patient, five years after resection by the Billroth I method. On the border between the stomach and duodenum, in the region of the suture, there could be distinctly seen a fold of mucosa (3.5 Mm. high) with a thickening of the muscular layer under it.

It would seem that the existence of a thickening of the muscular layer, rising in the region of the anastomosis, is not a matter of doubt, because it is already formed during the operation by means of connecting the seromuscular and mucous layers of the stomach and duodenum (Billroth I method), or of the stomach and a loop of intestine (Billroth II method). But it can be questioned, whether this thickening of the muscular layer will act as a sphincter. There is required for a sphincter. First, the existence of a muscular apparatus able to function actively, that is, able to produce active contraction and relaxation of its fibers, now narrowing, now enlarging the

opening surrounded by them. Second, the presence of a nerve apparatus which influences the sphincter in a reflex way and which provides the rhythm in its work.

The pyloric sphincter consists of muscular fibers, mostly of the middle layer, which circularly clasp the pyloric opening, close it on contraction and open it on relaxation. Quite another condition is obtained in the region of an anastomosis after gastrectomy. As already noted, the muscular thickening in this region consists of a muscular layer of the stomach (using the Billroth I method). While separating the stomach from the duodenum, the latter is usually cut transversally. Therefore, it is permissible to assume that a bunch of circular muscular fibers of the intestine is caught into the suture. Quite another picture obtains when cutting the stomach wall. Here it is doubtful, that one can calculate the cut during the operation so as to include a bundle of circular fibers into the suture of the stomach. Operating by the Billroth II method, we do not meet with such a bundle of circular muscular fibers in the muscular layer of the intestine because, while making the anastomosis, these fibers are usually dissected transversally, due to the fact that the opening of the intestine is formed by incising it along a section of its axis.

Moreover, muscular fibers introduced into the suture usually are soon penetrated by scar connective tissue which destroys their contractile activity. The existence of pronounced scar tissue over the muscular rollers in the region of the anastomosis was observed also by Bal in his "pap-rollers". Our histologic examinations show that formation of a scar tissue over the muscular rollers, that is, outside of them, is not so pronounced as the penetration of the muscular fibers by scar tissue. Seneque and Marx, came to the same conclusion. They could get no proofs of muscular fiber regeneration during the regeneration of the gastro-intestinal tract wall, nor could they find any such arrangement of muscular fibers which might be called a sphincter.

(In the illustrations submitted of the histologic preparations of sections made from the region of anastomosis in two patients (six and three years, respectively, after operation), the arrangement of the two muscular fiber layers can be seen. The thicker layer is that of the stomach wall, the thinner, that of the intestinal wall. The high magnification reveals that the muscular fibers of the muscular walls are wholly penetrated by connective tissue elements (Figs 1, 2, 3, 4). This penetration of muscular fibers by connective tissue elements is still more pronounced in the anastomosis of a dog's stomach, resected by the Billroth II method.)

The second condition required for a true sphincter is the presence of a reflex, automatic apparatus which can regulate the work of the sphincter. The pyloric sphincter functions mostly under the influence of the so-called Hirsch-Meining-Pavlov reflex which, though not being the only reflex controlling the function of the pylorus, nevertheless plays a prominent part. Many other agents influence the function of the pylorus, for example, the

mechanical irritation of the duodenal mucosa, reflexes on the part of other organs if they are pathologically involved (cholecystitis, cancer of esophagus) and probably many others. On removing the pylorus, this reflex bond is completely broken. Can the reestablishment of this bond after resection by the Billroth I method be expected, as suggested by Rosenblat? It is a matter of regret that the question of reflex bonds of the pylorus has not been studied enough in a healthy stomach. Therefore, it is difficult to contribute something definite to the question of the possibility of the reestablishment of these bonds after gastrectomy by the Billroth I method, or of the formation of a new automatic reflex, as suggested by Bremer and Held. Thus, there are no data, either anatomic or physiologic, which could be used to prove the existence and functioning of such a sphincter.

As regards operation by the Billroth II method, there can be no justification to consider the existence of a sphincter around the anastomosis, because, first of all, there is absent the principal element of a sphincter, namely, circular muscular fibers.

The fact of the presence of a zone of clarification observed in the region of the anastomosis on radioscopy of the resected stomach, creates the impression of the existence of a sphincter. These zones may be observed in individual cases after resection both by the Billroth I and II methods. We observed such zones of clarification in the region of anastomosis in seven of our patients. In some of them this phenomenon was systematically repeated at every roentgenologic examination at various intervals after the operation, ranging from three months to four or five years. In several cases, such a clarification "sphincter" was observed only during the first period after operation and then disappeared, and could not be duplicated on further radioscopy.

This lighter strip in the region of anastomosis, with the contrast medium passing through it, is judged by some investigators as a proof of the existence of a "sphincter." It seems to us that the presence of this zone of clarification is completely explained by the thickening in the region of the suture of the anastomosis, created by the doubling of the two walls, namely, the gastric wall and that of the intestine.

On the basis of the above, we feel justified in challenging the possibility of a sphincter or a "quasi-pylorus" (Beresov) formation in the region of the anastomosis after gastrectomy by the Billroth I or II methods. Nevertheless, the fact of a rhythmic type of evacuation of the stomach after its resection remains and has been proven by our observations, as well as by those of Schindler, Moutier, Heitel and Calus. This fact requires explanation. We consider that the change in resistance which at times permits the contrast medium to be periodically carried through the anastomosis, and at other times compels retention above it, may be explained by the contraction either of the loop of the lean intestine, adjacent to the stomach, or by that of the duodenum. Mehling, in 1897, at the 15th Congress of Therapeutists, on the basis of his work on duodenal fistula, carried out on the resected stom-

achs of dogs, reported that evacuation takes place neither faster nor slower than in the healthy stomach. It is accomplished at intervals, periodically under relatively great pressure, and the evacuation is regulated by the degree of filling the duodenum.

Cannon also points to the rhythmicity of contraction of the duodenum as the force restraining evacuation from the resected stomach and compensating for the contraction of the pylorus. Kochev considers that any contraction of the loop of intestine below the anastomosis can restrain evacuation. Hertel, Bürgfeld, Kalmanovsky, Seneque and Marx are also of the same opinion. Schindler and Dagayev, likewise, emphasize the existence of definite relations between the functioning of the anastomosis and the condition of the intestine. Our observations confirm the correctness of this opinion.

On a radioscopy of one resected stomach we noticed a new detail concerning evacuation which we were able to confirm in nearly all subsequent cases (in 93 out of 132). After the first swallow of the contrast medium, the first part of the meal slides down at once without meeting any resistance through the anastomosis into the efferent loop. Then the remaining part, and the newly swallowed portions of the contrast medium, which for some time were kept detained over the anastomosis, began their rhythmic (though not always at equal intervals) evacuation by definite amounts through the anastomosis into the efferent loop.

Involuntarily, the thought arises that the first portion of the contrast medium, on its passage from the stomach through the anastomosis into the efferent loop, evokes by irritation of the mucosa such a peristaltic movement in the loop of the intestine which reacts to unlock the anastomosis after its period of closure. We know from physiology the so-called law of intestinal movement which states that the loop of intestine contracts over the bolus of food and dilates beyond it in such a manner that, having carried this bolus of food farther on, it contracts—during which the distal part of the intestine dilates. A contraction of the intestinal loop results from the contraction of a bundle of circular fibers, the so-called stratum circulare, which represent a rather stronger layer. If an anastomosis is effected either by the Hacker-Eiselsberg method or by any other modification of the Billroth II method (not including the Roux modification) the opening in the intestine is made by dissecting it along its axis. It follows that all circular muscular fibers are transversely cut. These, when contracting, will tend to result in a maximum drawing away of the edges of the opening, thus opening the anastomosis between the intestine and the stomach. The closing of the anastomosis will take place when this intestinal loop again becomes relaxed. Then the contraction of circular fibers will cease, together with the drawing away of the edges of the anastomosis. Simultaneously the fibers of the stratum longitudinale begin their contraction and bring the edges of the anastomosis still nearer together.

Such a type of evacuation which is regularly observed, practically on each radioscopy of the resected stomach, we consider as the normal type of

evacuation for a resected stomach. This opinion on the manner of evacuation of the stomach resected by the Billroth II method, I expressed in 1935, and it entirely coincides with the conception of Seneque and Marx, published in January, 1936. These observers as well as Bergeret and Caroli have met with the above described type of the evacuation from stomachs resected by the Billroth I, as well as by the Billroth II method.

It can be assumed that in a considerable number of the remaining 32 patients, examined earlier, who showed at the time of radioscopy only the presence of a rhythmic evacuation, the latter took place also in the manner which, from our point of view, is normal for the resected stomach.

Rhythmic evacuation does not always proceed in equal intervals of time. Cases were met with in which even, in the same patient, we observed unequal intervals between passage of two portions of the contrast medium through the stoma of the anastomosis, sometimes at longer and sometimes at shorter intervals. There were individual cases, where after passage of the first portion of a contrast medium through the stoma, there was observed a period lasting from two to three minutes, in which the stoma was closed followed by the usual rhythmic evacuation. Sometimes even the first portion of the contrast medium did not pass through the stoma, but remained above it for more or less long periods of time. Only a dose of an additional amount of the contrast medium, resulting in an increased hydrostatic pressure finally pushed it into the efferent loop by the help of active peristaltic movement.

We had nine such cases. This phenomenon becomes evident if there is taken into consideration that this was observed exclusively during the first period of time following the operation. In five patients we observed it in from two to three weeks after operation, in four, from one to two months, and only in one patient in six months post operation. In this period, the edges of the anastomosis as well as the wall of the adjacent intestinal loop are in a state of increased sensitiveness toward any irritation in consequence of the inflammatory edema of healing, hematoma, etc.

In some cases there may exist other reasons accounting for such a spastic contraction of the region of anastomosis after swallowing the first portion of a contrast medium. In patients who had undergone gastrectomy for cancer of the stomach, this type of evacuation presented the first symptoms of a cancer recurrence, still unrevealed by other radioscopic or clinical manifestations. Continued observation of these patients showed, indeed, the development of cancer recurrence in the region of a gastric stump. We consider our hypothesis quite acceptable, because cancer in the region of any natural apertures, such as cardia, pylorus, the urinary bladder neck, etc., is usually accompanied with a secondary spasm of the adjacent musculature.

The Efferent and Afferent Loops of the Intestine After Gastrectomy—Rhythmic evacuation of the resected stomach plays an enormous part in the whole further process of digestion. It is impossible in the present article to discuss in detail questions of the chemistry of digestion after gastrectomy. We may call attention only to the fact that albumins and fats were not reacted

on chemically during their stay in the gastric stump. Pepsin digestion is absolutely absent, while trypsin enters the stomach through the stoma of the anastomosis only in traces, and even this not always. Chemical treatment of the food begins from the moment the food leaves the stomach, to come into contact with the duodenal juices in the efferent loop. The mixing together of food and duodenal juice will be more complete if food enters the efferent loop not as a continuous stream, but rhythmically and in definite portions, such as we had met with in all our observations. The mixing together of food with the duodenal juices takes place, first, in the part of the efferent loop nearest to the anastomosis. This segment gradually dilates, reaching in some cases to rather considerable dimensions and forms the so-called "*nachmagen*." In the "*nachmagen*," food is retained for some time (from $\frac{1}{2}$ to 1 minute), undergoing agitating movements, then it is evacuated farther along to the efferent loop. Such a "*nachmagen*" we could observe in 21 cases, and in 15 cases it appeared only in six months after the operation. In no case did we observe the "*nachmagen*" earlier than in one month after operation. By their function the segments of the efferent loop nearest to the anastomosis are closely related to the resected stomach, this fact made Seneque and Marx assimilate them into one "gastro-intestinal block."

The segments of the efferent loop nearest to the anastomosis are more subject to the constant influence of little changed food than all the other small bowel. In consequence of this its mucosa suffers a considerable change. The Kerkring folds become thicker, sometimes taking on a loop-like character.

These observations force us to establish, at least radioscopically, the development of chronic catarrhal inflammation of the mucosa in the efferent loop (jejunitis chronica). True, these catarrhs in some cases disappear, as we observed in five cases, but for the most part they remain for years, though not always accompanied by any clinical manifestations. The afferent loop rather often became filled with the contrast medium (in 37 out of 132 cases, *e g*, in 28 per cent of the cases), but only at its beginning. In two cases the filling extended a rather considerable distance, and in two other cases it even reached the bulbous duodenum. In these cases, the contrast medium was returned back into the stomach by peristaltic movements after a short time. When the contrast medium entered only the initial part of the afferent loop, it was returned almost instantly into the stomach.

The Gastric Mucosa After Resection—The data furnished by Meyer-Burgdorf, Henning, Wanke, Haberer, Konjetzny, Redwitz and others, suggest that the presence of a rough, changing aspect of the gastric mucosa is one of the causes of dyspeptic troubles. Konjetzny, Puhl, Chiarì, on microscopic examination of the resected stomach wall, found reddening, edema of the mucosa, and enlarged lymph nodes. The microscopic examination by these authors revealed changes corresponding to acute as well as subacute and chronic inflammatory processes such as degeneration of epithelial cells, fibrous leukocytic exudation in the intercellular space, connective tissue in the muscular layer and submucosa, and hyperemia and inflammatory edema up

to the muscular layer. All these manifestations developed independently of the presence or absence of gastritis before the operation and, therefore, should be considered as secondary processes connected with the changed processes of digestion in the resected stomach.

Opposed to this, Biemer and Held discovered no secondary gastritis in the resected stomach. They explain the presence of thickened folds by welling of the mucosa in consequence of limitations to the lymph stream after dissection of a large number of longitudinal lymphatic paths.

Out of 132 observations, we gathered data on the aspects of the gastric mucosa in 112 cases. Only in 22 cases (19.6 per cent) the folds of the mucosa were not thickened and showed normal direction. All persons examined were quite healthy. The same aspect of mucosa was found in these patients only in from one and one-half to two or three years following the operation. Examination of the same patients sooner after the operation (within six months or one year) invariably revealed pronounced thickening of the mucosal folds showing anomalous direction, sometimes presenting a loop-like aspect. In the remaining 90 cases we observed a considerably changed aspect of the gastric mucosa, its folds were thickened and their course anomalous, especially soon after the operation. Later on, in most cases, the folds took on a more normal direction, but still remained thicker. Only three of these patients felt pressure after taking coarse food or after an abundant meal. All others suffered no discomfort, such as heart-burn, belching, or epigastric pressure. They fed themselves on their customary food without observing the diet.

Such a complete absence of complaints on the part of patients after gastrectomy in spite of fluoroscopic evidence of changes ascribable to the chronic gastritis, might lead to the conclusion that gastritis finds its place after resection, and to the acceptance of the point of view of Biemer and Held.

But the difficulty of recognition of chronic gastritis lies in the fact that the signs which "doubtless characterize a disease, namely, the pathologo-anatomic changes of mucosa, do not always coincide with those symptoms by which a disease is usually named by a doctor or a patient" (Lurya). The above described macroscopic and microscopic evidence obtained by us and by other investigators on examination of the gastric wall, the fact of the presence of a changed relief in the gastric mucosa in the overwhelming number of our cases—all point to the existence of chronic inflammation in the resected stomach mucosa.

Our histologic examinations both of the gastric wall in a patient in four and one-half months since resection, and of the gastric wall after resection in a dog, confirm the presence of considerable changes of an inflammatory type.

All this compels us to share the opinion of those who maintain the presence of a chronic gastritis in the resected stomach. All conditions are present for the development of such a gastritis. Frequent disturbances in the order and type of a food reception are doubtless predisposing factors to the formation of a chronic irritative gastritis in an unoperated stomach. Such predis-

posing conditions include the reception of badly masticated food in consequence of the lack of teeth, as well as the hasty ingestion of it. The resected stomach mucosa in consequence of the lack of the antrum, diminished peristalsis, and the small dimensions of the stomach should react still more definitely to such chronic disturbances. Even if there is omitted from consideration the debatable questions concerning the influence of the lack of hydrochloric acid and pepsin, or the influence or presence of the duodenal and intestinal juices in the stomach, all other conditions being equal there are more chances for development of gastritis in the resected stomach than in the normal one. Chronic gastritis in an unoperated stomach is often developed without any clinical symptoms or with very insignificant ones. The

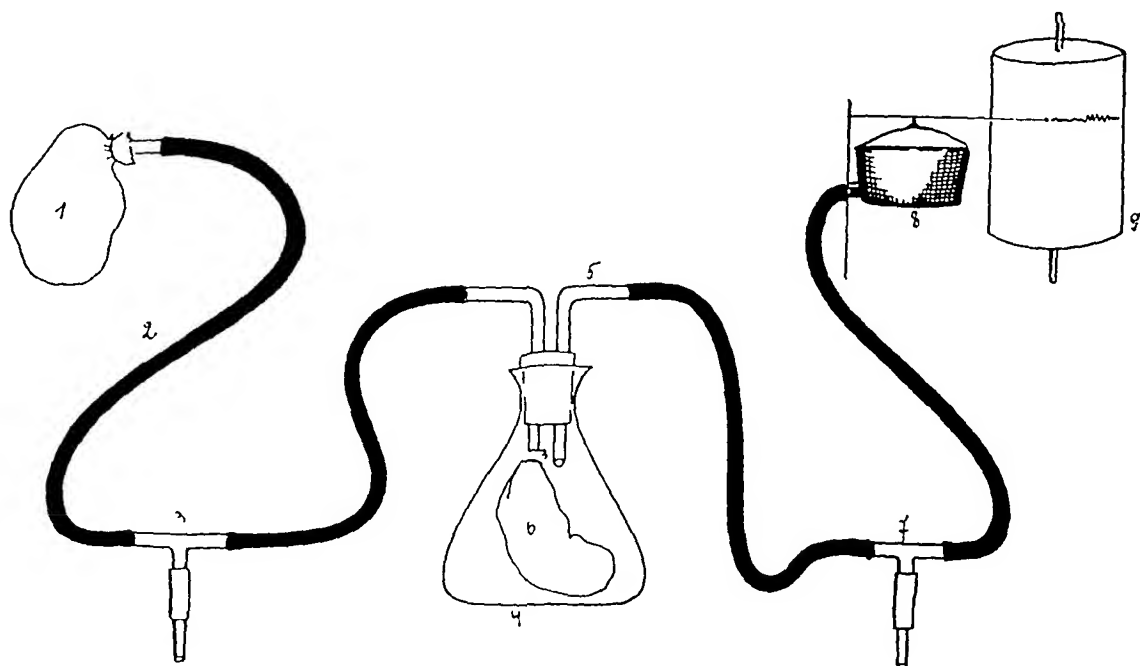


FIG. 1—Schematic representation of the apparatus used for registering the contraction curves in the region of the anastomosis

same fact is met with in the resected stomach. In many cases observed by us (109), this chronic gastritis was quite symptomless. In some cases patients considered themselves to be quite healthy, paying no attention to slight epigastric pressure after the reception of abundant food, or after a hastily consumed meal, because these phenomena disappeared quickly and did not manifest themselves after slow eating or on the reception of food in small quantities. Only in rare cases (eight patients in our series) were these feelings more constant.

Motor Function in the Resected Stomach on the Basis of Experimental Data—Our own clinical and roentgenologic observations on the motor function in the resected stomach showed that gastric evacuation through the anastomosis occurs, as a rule, rhythmically in definite lapses of time. Considering the possibility of the formation of a new sphincter in the region of anastomosis to be a very doubtful one, and taking into account the literature, as well as the data of our own (unfortunately too few) microscopic examinations, I

believe that the periodical closing and opening up again of the anastomosis represents a complicated process which can be best explained by the contractive activity of the gastric walls themselves taken with, but subordinated in importance to peristaltic movements of the loop of intestine sewed to the gastric stump

Assuming that the peristalsis of the sewed up loop of intestine takes place in a reflex way, in consequence of irritation to its mucosa by a portion of the contrast medium passing through the anastomosis, I decided to check this

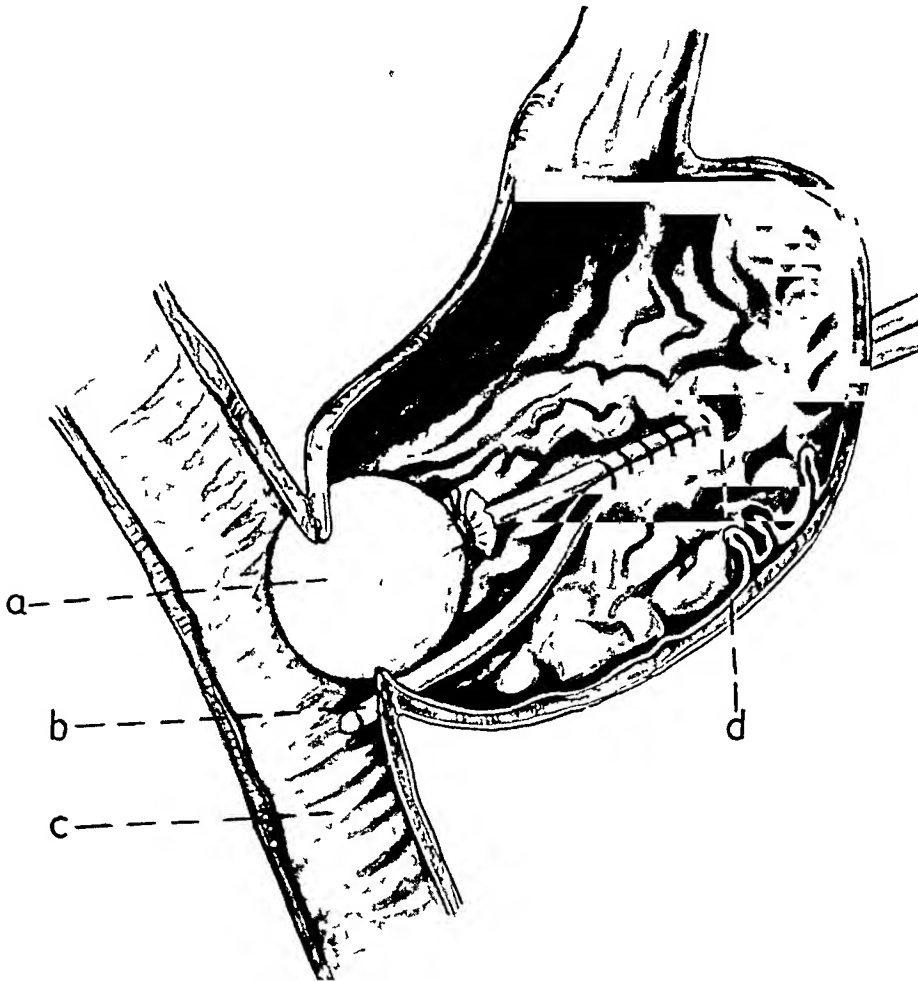


FIG 2—Schematic representation of a resected dog's stomach with a balloon introduced into the stomach of the anastomosis (a) Rubber balloon (1 in Fig 12) (b) Rubber tube through which Ringer's solution is introduced into the outgoing part of the loop (c) The intestinal loop (d) Stomach fistula

suggestion experimentally on a dog using Danielopolu's method. The contractions of the gastric walls, or of the anastomosis, are transmitted by a thin rubber balloon to a Marey capsule and registered with a kymograph. For this purpose at the end of a thick-walled rubber tube (0.5 cm diam) we fixed a small rubber balloon. This rubber tube was connected by a tee with a damper consisting of a small flask provided with a tight fitting cork, through which passes a short tube, ending just under the cork, and a long tube to the opposite end of which is fixed a small rubber balloon. The short glass tube

of the damper through a second tee is connected with the Maerey capsule the needle of which, touching the kymograph, makes the necessary records

By blowing air through the tee we distend the rubber balloon at the end of the rubber tube, simultaneously distending the rubber balloon in the damper. The air space remaining in the latter is connected with the kymograph with the tube. Vibration of the balloon transmitted to the balloon is recorded upon the kymograph, resulting in a definite curve.

Gastrectomy was performed upon a dog by the Hacker-Eiselsberg method. Three and one-half months later a gastric fistula was made in the same dog through which, under finger control, the thin rubber balloon was introduced.

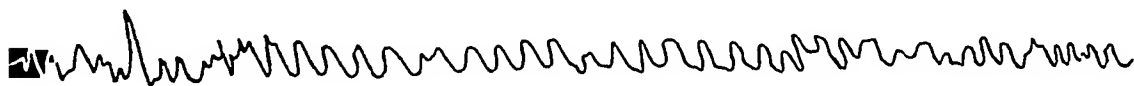


FIG 3—Gastrogram No. 1

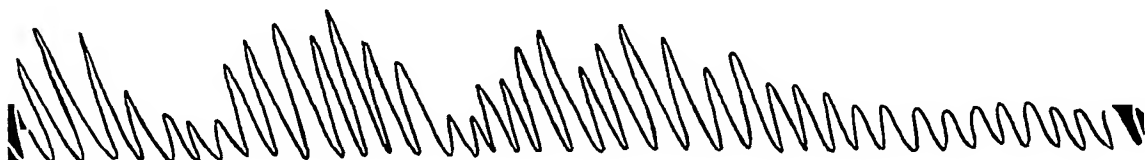


FIG 4—Gastrogram No. 2



FIG 5—Gastrogram No. 3

and fixed in the lumen of the anastomosis. In the state of rest, or in the absence of irritation of mucosa of the efferent loop of stomach, the region of anastomosis showed the absolute absence of contractions on the kymograph.

Zigzags of the curve reflecting the breathing movements of the diaphragm follow each other showing nearly no change in their amplitude or type.

On irritating the efferent loop mucosa with Ringer's solution, we observe that after some lapse of time, the anastomosis closes and then opens again. The corresponding gastrographic curve rises and falls, giving rise to a typical wave. In the same way a second wave is formed, having lesser amplitude, then a third wave, and so on. On irritation of the intestinal mucosa we create its peristalsis in the region of irritation. Thus peristaltic contraction of the intestinal loop, adjacent to the stomach, evokes the opening of the anastomosis, while its relaxation produces a corresponding closing. This

is seen from the gastriograms Nos 1, 2, and 3. Intestinal peristalsis evoked by irritation of its mucosa does not cease at once with the elimination of irritation, but lasts for a certain length of time, gradually abating.

Corresponding to this, the gastrographic curve shows the more remote waves with lesser and lesser amplitude.

By irritation of the mucosa only of the stomach (as in experiment 3), there is obtained another type of curve illustrated by gastrogram, which shows atypic waves of very low amplitude, and these waves do not alternate with each other so regularly as in the former gastriograms. This might be construed to mean that the muscular wall of the gastric stump on irritation of its mucosa also participates in the closing and opening again of the anastomosis, but this participation is a very insignificant one.

CONCLUSIONS

(1) As a rule, the stomach resected by the Billroth II method shows a rhythmic evacuation. This type of evacuation is observed both on resection by the classic method of Billroth II or by its Hacker-Eiselsberg or Kionlein-Reichel modifications.

(2) In order to obtain rhythmic evacuation from a stomach resected by the Billroth II method, there is no need to complicate this operation by further modifications *e g*, the operation by Finsterlin, Bal, Goetze and others.

(3) The type of evacuation obtained does not depend upon the extent of the resected region, the rhythmicity of evacuation is observed on subtotal gastrectomy.

(4) There is no difference in the type of evacuation obtained in stomachs resected by the Billroth I and or by Billroth II method.

(5) At present there are no data which would substantiate the belief in the formation of a sphincter in the anastomosis region after gastrectomy. Following resection by the Billroth II method, we consider such a formation to be quite impossible.

(6) The periodic closing and opening again of the anastomosis are explained in the main by peristaltic contractions and distensions of the efferent intestinal loop nearest to the anastomosis.

(7) Gastric tone after a partial gastrectomy becomes normal in time, a hypotonic or atonic stomach becomes normal in tone.

(8) Spasms of the anastomosis after gastrectomy undertaken for cancer present an early symptom of a recurrence of the cancer in the region of anastomosis.

(9) After gastrectomy, most patients exhibit hyperplastic gastritis, though without any subjective manifestations.

(10) After gastrectomy, chronic jejunitis follows, also without clinical manifestations.

(11) Normal evacuation of the stomach, resected by the Billroth II method, or by its Hacker-Eiselsberg modification, is in complete accord with their general condition of good health which gradually improves with the passing years.

SUBPARIETAL RUPTURE OF THE INTESTINE DUE TO MUSCULAR EFFORT

REPORT OF TWO CASES

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THE subject of subparietal rupture of the intestine due to muscular effort was recently reviewed by Wilensky and Kaufman¹ After a careful search of the literature the authors accepted 42 cases as genuine examples of this condition and added one case of their own

Direct injury to the underlying intestine as a result of a penetrating wound of the abdominal wall is so frequent as to occasion no comment It has also been long recognized that the intestine may be ruptured notwithstanding the presence of an intact abdominal wall This injury may be of the bursting type, as in cases where air is forced under pressure into the rectum and sigmoid colon, or the tearing or crushing type seen where there has been some sudden blunt force applied to the abdominal wall Excluding the foregoing types of intestinal injury there remain those cases, reviewed by Wilensky and Kaufman, in which muscular effort alone was apparently the cause of the intestinal rupture Various theories have been advanced to explain how this could happen According to the theory of Bunge,² as later modified by Ham,³ contraction of the abdominal muscles and diaphragm in severe muscular effort compresses the bowel and causes an elevation of pressure within the intestinal lumen This rise in pressure is transmitted equally to all parts of the bowel and abdominal wall under normal conditions If there is a point of weakness in the abdominal parietes, for example at the inguinal rings, the bowel wall will be unprotected in this place, permitting a bursting type of rupture of the bowel to occur In support of this theory, Wilensky and Kaufman point to the fact that hernia was present in 33 of the 43 cases which they reviewed

The subject of subparietal rupture of the intestine due to muscular effort also has definite medicolegal importance If the muscular effort is in the course of employment, whether hernia is present or not, the resulting disability should be compensable In the case of Wilensky and Kaufman and that of Wiedhopf,⁴ compensation was granted, as it was in the second case reported herewith

CASE REPORTS

Case 1 (SFM) —G C, white, male, age 49, was admitted to the Ellis Hospital, November 3, 1933, with a history of having been working on a platform which was part way up a runway leading to the top of some concrete forms His task was to guide the wheelbarrows pushed by co-workers around the curve on the platform and give them a push to start them up the second runway The second runway was about 16 feet long

Submitted for publication December 8, 1938

and the loaded wheelbarrow weighed about 150 pounds. After he had been working for a few minutes at this job he was suddenly seized with abdominal pain and fell to his knees. He was immediately taken to the hospital.

Physical Examination—The patient was examined one hour and a half after the onset of his illness. He denied previous abdominal trouble or indigestion. Examination disclosed a well developed and nourished man of powerful physique. The abdominal muscles were in a state of board-like rigidity and there was marked abdominal tenderness throughout. Temperature 100.4° F, pulse 115, blood pressure 145/85. *Diagnosis*: Perforated peptic ulcer.

Operation—Immediate celiotomy under spinal anesthesia was performed, through a right rectus incision. The peritoneal surfaces and omentum were found to be injected. The peritoneal cavity contained a considerable quantity of grayish-yellow fluid in which were strands and particles of what appeared to be partly digested food. Examination of the stomach, duodenum, gallbladder, appendix and region of the pancreas disclosed no abnormalities. It was then discovered that the fluid was escaping from a perforation in the jejunum. The perforated loop was located in the left upper abdominal quadrant. The perforation was 1.5 cm in diameter and seemed to be about opposite the mesenteric attachment. There was no induration or scarring around or adjacent to it and the mucosa everted or pouted out around the margin. The perforation was closed in the long axis of the intestine, using two layers of continuous fine linen suture. The fluid was sucked and sponged out. The abdomen was closed without drainage. Smear of the fluid disclosed the presence of occasional red cells and a rare gram-negative coccus. *Staphylococcus* was reported on culture.

Postoperative Course—During the first 24 hours after operation the condition of the patient remained satisfactory, the pulse being about 100, temperature 104° F. On the second day his condition became rapidly worse. The urinary output decreased and the urea nitrogen was found to be 88 mg per 100 cc. In spite of intravenous administration of saline and glucose, the patient expired on the second postoperative day.

Autopsy (Dr. Kellert)—This was limited to an examination through the operative incision. When the abdomen was opened considerable brownish-yellow fluid mingled with greenish-yellow flocculi escaped. The peritoneal surfaces were everywhere covered with grayish-yellow, fibrinous, plastic exudate, particularly in the pelvis and epigastric regions. The appendix, mesenteric lymph nodes, pancreas, gallbladder, bile ducts and liver were normal. The spleen was enlarged to twice the normal size. The stomach was markedly distended but otherwise not remarkable. The duodenum showed considerable injection of the mucosa but there was no evidence present of ulceration or inflammation. The jejunum was normal throughout except at one point near the middle portion where a small opening had been recently sutured. About this opening the mucosa was hemorrhagic but there was no inflammatory or ulcerative process visible. The opening was situated near the mesenteric border and did not leak. The ileum was normal. There was no enlargement or ulceration of Peyer's patches. The colon appeared normal except at the terminal portion where diverticuli were found. None of these was greater than 0.5 cm in depth and there were no associated inflammatory changes. No foreign object was found in the intestine or peritoneal cavity. The kidneys and genitalia were normal.

Pathologic Examination—*Microscopic* Sections from various portions of the intestine showed changes limited to the serosa and adjoining musculature. On the serosa was found a thick layer of pus cells and fibrin and numerous particles of necrotic vegetable material. At the site of the rupture there were marked acute and subacute inflammatory changes and suture material *in situ*. The mucosa was intact and did not show inflammatory changes. The small arteries showed intimal thickening and hyaline change.

Case 2 (A. G.)—S. S., white, male, age 52, was admitted to the Ellis Hospital, January 7, 1938, with a history of having been engaged in moving carboys, one of which slipped, necessitating an extraordinary effort to prevent the vessel from falling. While

doing so he felt an immediate, severe pain in the right upper abdominal quadrant. He was not struck in the abdomen.

Physical Examination—The patient was examined two hours after the onset of his illness. He was a well developed, poorly nourished man of asthenic habitus. He complained of severe abdominal pain. There was marked rigidity of the abdominal muscles with tenderness to palpation over the entire abdomen. Leukocyte count 15,000.

Operation—Immediate celiotomy was performed under cyclopropane anesthesia. A para-umbilical, right rectus incision was made. The peritoneal cavity contained free fluid and particles resembling intestinal content. Multiple particles of plastic exudate were found on the serosa of various loops of the bowel. The omentum was edematous. A small perforation of the ileum was discovered through which gas bubbles and intestinal contents were escaping. The opening was closed in two layers, using a continuous silk suture. A stab wound through McBurney's point was made and a cigarette drain inserted. Another cigarette drain was placed into the pelvis through the lower angle of the primary incision.

Postoperative Course—The patient made slow but satisfactory recovery. The temperature returned to normal on the sixteenth day. The patient was dismissed on the twenty-eighth day following operation and allowed to return to work after two months.

COMMENT—In neither of the cases was an inguinal or other type of hernia found. In the first case none was found at autopsy, and strangulated hernia was ruled out before the operation. It is possible that areas of structural weakness of the abdominal wall, as suggested by Wilensky and Kaufman, were present. No careful search for such finding was made at the autopsy in the first case. In the second case the patient was carefully examined by a physician attached to the compensation court before he returned to work, who reported that no hernia was present. In both cases testimony was taken before the compensation court and it was clearly proven that there had been no trauma to the abdominal wall.

Medicolegal Aspect—In Case 1, which terminated fatally, the widow, through her attorney, brought action in the local compensation court of the New York State Division of Workmen's Compensation against the employer to recover an award for her husband's death. There was considerable medical testimony given on both sides with the outcome depending upon the question of whether or not there was a preexisting ulcer present. The referee finally disallowed the claim after having the Chief Medical Adviser examine the evidence. The referee concluded that the exact cause of the perforation was not definitely shown but that the weight of medical evidence was to the effect that it was not due to accidental injury arising out of and in the course of employment. This verdict was appealed to the Board, where it was sustained. In Case 2, which terminated in recovery, before the same compensation board at a later date, award of compensation was given, there being no contest on the part of the carrier and no question as to the direct causal relationship between the man's employment and the perforation of the ileum.

SUMMARY—Two cases of subperitoneal rupture of the intestine due to muscular effort are submitted. In neither instance was there a blow or other injury of the abdominal wall and in neither was a hernia found. In one case compensation was awarded and in the other it was not.

Case 2 was a patient of Dr Albert Grussner, Schenectady, New York, and acknowledgment is made of his kindness in allowing it to be reported herewith

REFERENCES

- ¹ Wilensky, A O, and Kaufman, P A Subparietal Rupture of the Intestine Due to Muscular Effort ANNALS OF SURGERY, 106, 373-393, September, 1937
- ² Bunge Zur Pathogenese der subkutanen Darmrupturen Beitr z klin Chir, 47, 771, 1905
- ³ Haim, F Beitrag zur Pathogenese der subkutanen Magen-Darmrupturen Arch f klin Chir, 93, 685, 1910
- ⁴ Wiedhopf Beitrag zur Perforationsruptur des Dunndarms ohne Bauchtrauma Zentralbl f Chir, 56, 39, 1929

THE USE OF SULFANILAMIDE IN THE TREATMENT OF PERITONITIS ASSOCIATED WITH APPENDICITIS

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THE MORTALITY of appendiceal peritonitis has not shown a general decline during recent years in spite of the numerous advances in pre- and postoperative care^{1, 2, 3}. In this clinic we have been able to show an improvement in mortality following the addition of sulfanilamide to the routine treatment of the severe cases of appendicitis. Although the series since the addition of sulfanilamide to the routine therapy has not been large and the data may not be statistically significant, we are convinced by the clinical evidence that sulfanilamide therapy subsequent to operation has ameliorated the severity of the reaction in spreading peritonitis in many cases and has saved some lives that otherwise would have been lost.

The value of sulfanilamide in hemolytic *Streptococcus* infections was first determined in the peritoneum of the mouse,⁴ and its effectiveness in patients was first demonstrated by Colebrook^{5, 6} in puerperal sepsis in which peritonitis is a common cause of death. The drug has probably not been employed extensively in other types of peritonitis because it was introduced as a specific therapeutic agent for hemolytic *Streptococcus* infections, though it has been used successfully in the treatment of colon bacillus infections of the urinary tract.

In the latter part of 1936, we began the use of sulfanilamide in spreading peritonitis associated with acute appendiceal infections and in those instances where it was feared that a spreading infection might develop.

Results—It is a fortunate circumstance that two of the authors were concerned with the operations upon the patients in the earlier group and in large part on those in the sulfanilamide treated group. Surgical technic, anesthesia, and pre- and postoperative therapy were the same in both groups.

Shortly after starting the use of sulfanilamide postoperatively in the severe cases of appendicitis with peritonitis, death occurred in a patient operated upon for acute appendicitis. The infection in this patient was not severe at the time of operation and sulfanilamide was not begun until the third day after operation when the patient had evidences of a very widespread infection. At autopsy the spreading infection was found to be due to a blown-out stump.

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Submitted for publication June 22, 1939

Since then 250 consecutive cases of acute appendicitis have been operated upon on the service of the senior author at the Hospital of the University of Pennsylvania without a death from any cause

Table I is a compilation of the mortality figures with acute appendicitis and its complications on the same service, from its inception. The diagnosis in these cases has rested on the findings of the surgical pathologist who examined the appendix grossly and microscopically, except in an occasional case of abscess in which the appendix was not removed

TABLE I

THE MORTALITY FROM ACUTE APPENDICITIS AND ITS COMPLICATIONS

Service E, Hospital of the University of Pennsylvania

	Total Cases	Deaths	Drained Per Cent	Gross Mortality Per Cent
Before the use of sulfanilamide (to 1936)	552	8*	37 0	1 4
With the use of sulfanilamide (1936 to May, 1939)	257	1†	43 0	0 4
Total	809	9	38 0	1 1

* One death occurred in a patient not operated upon

† This patient did not receive sulfanilamide until three days after operation

The operations were performed by men who had completed their internships from two months to 20 years previously. In the earlier part of the series, the majority of the operations were performed by the chief of service. In the latter period the greater number were performed by surgical fellows.

Summaries of two case histories are given to illustrate the clinical course of very ill patients who were operated upon and then treated with sulfanilamide. Many other cases of widespread peritoneal infection could equally well be presented.

ILLUSTRATIVE CASE REPORTS

Case 1—Hosp. No. 39563 (Surgical). J. G. F., white, male, age 59, was admitted to the Hospital of the University of Pennsylvania, June 23, 1938, complaining of severe generalized abdominal pain. Abdominal discomfort had begun two days previously, but it remained mild until the morning of the day of admission, when it rapidly increased in severity and pain was referred to the right shoulder.

At the time of admission there was widespread rigidity with accompanying tenderness and rebound tenderness. Peristalsis was suppressed. Rectal examination was negative except for prostatic hypertrophy. Temperature by rectum was 100.8° F., pulse 100, respirations 28. W. B. C. 14,000, hemoglobin 92 per cent.

Roentgenologic examination showed no air under the diaphragm. A diagnosis of ruptured peptic ulcer was made and celiotomy performed through an upper right rectus incision. The peritoneal cavity was filled with frank pus. Both surfaces of the liver were bathed with it. No perforation of the stomach or duodenum was found. The origin of the pus proved to be a ruptured appendix.

The appendix was removed and a drain was introduced through a stab wound in the right lower quadrant. As the wall of the cecum was necrotic, a rubber catheter was introduced and the cecum closed around it.

Sulfanilamide was administered hypodermically every six hours. The total dose was

6.4 Gm the first 24 hours, 8 Gm the second 24 hours, 6.4 Gm the third 24 hours followed by 4.8 Gm per day. After the fifth day oral administration was used with gradually diminishing doses. The drug was stopped on the eighth postoperative day. Recovery was complicated by a psychosis characterized by disorientation and hallucinations.

The highest temperature, 103.4° F by rectum, was recorded shortly after operation. The temperature declined by lysis over a period of ten days. The pulse rate was compatible with the temperature at all times.

Case 2—Hosp No 39401 (Surgical) J. R., white, male, age 25, was admitted to the Hospital of the University of Pennsylvania, June 4, 1938, complaining of abdominal pain. The patient had had his first symptoms, nausea and vomiting, May 31, 1938. The following day he complained of abdominal pain. Localization of the pain occurred two days prior to admission and on the day of admission again became generalized.

At the time of admission the patient was evidently very ill. The abdomen was diffusely rigid and distended. Peristalsis was hardly audible. Shortly after admission the temperature was 104.2° F by rectum, pulse 130, WBC 17,400. Operation was performed under spinal anesthesia through a McBurney incision. Considerable purulent material was present without any evidence of localization and liquid feces were found about a perforated appendix. The appendix was removed and drainage instituted. Culture showed *Escherichia coli*, nonhemolytic *Streptococci* and *Clostridium welchii*.

Sulfanilamide was given by hypodermoclysis starting with a single dose of 4.0 Gm. The dose was 8.8 Gm for the first 24 hours, 5.6 Gm for the second 24 hours, and was then gradually reduced. The drug was stopped on the tenth postoperative day. The clinical chart showed a severe but subsiding reaction in a patient whose chances of survival seemed poor at the time of operation.

In order to afford a background for the results we have obtained, it is necessary to present certain statistical data regarding the series* and to outline the routine management employed. The age incidence of acute appendicitis in this series is shown in Chart 1. It is similar to that found by numerous others who have reported on the age incidence as observed in a general hospital.

Of the 780 cases 300, or 38.4 per cent, were drained. Peritonitis, mild to severe, localized or nonlocalized, was encountered in 355 patients (45.5 per cent). This apparently high incidence of peritoneal involvement is due to the fact that only patients in which the appendix, by histologic examination, showed acute diffuse suppurative appendicitis or more advanced disease have been included in this report. Gross perforation in the nonlocalized cases was demonstrated in 77 instances (9.9 per cent). Localized abscess was found in 51 patients (6.5 per cent).

Ileus, requiring enterostomy, occurred in nine patients. All of the enterostomies, except one, were performed prior to 1933, when the use of suction drainage as suggested by Wangensteen and Paine⁷ was begun. The exception was in a young boy with a hemolytic *Streptococcus* infection which invaded the retroperitoneal tissues and which was associated with an ileus of the adynamic type. Sulfanilamide would probably have saved his life.

The most common organisms cultured from the peritoneal exudate were, in order of their frequency (1) *Escherichia coli*, and (2) *Streptococci*—

* The statistical analysis is based on 780 consecutive cases up to January 1, 1939. The mortality figures include the cases up to May 15, 1939.

hemolytic and nonhemolytic. Anaerobic cultures were not made in a large enough group of patients to be of statistical value.

Residual collections were drained in eight cases. It is interesting to record the fact that four of these occurred since beginning the use of sulfanilamide. It is possible that the drug favors local abscess formation but it is more likely that localization occurred in patients who before the use of sulfanilamide would have succumbed to a spreading peritoneal infection.

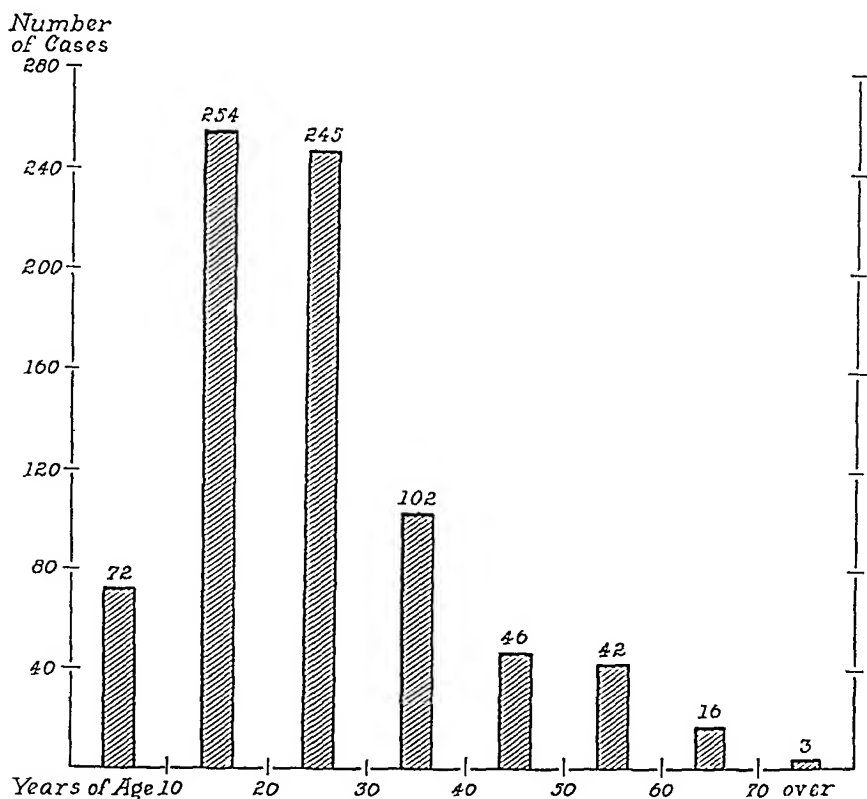


CHART 1—Age incidence in acute appendicitis
(Service C, Hospital of the University of Pennsylvania)

Jaundice has been observed three times since beginning sulfanilamide therapy. In one patient this may have been due to hemolysis following the administration of the drug. In no instance did liver injury go on to abscess formation.

Routine Management—Operation was carried out as soon as possible after admission to the hospital in all children, in all patients in whom pain started in the right lower quadrant, and in all other cases except for a few who arrived at the hospital late in the course of the disease in whom it was thought that localization of a peritonitis was occurring or that an abscess had formed. In the patients who presented signs of fulminating peritonitis the tendency has been more and more toward early operation (after one to two hours of the intravenous administration of a 5 per cent glucose and physiologic saline solution). Excepting clear-cut cases of appendiceal abscess which need not be regarded as emergencies, operation was delayed in less than 2 per cent of the cases.

Anesthesia —In patients over 15 years of age, spinal anesthesia was employed whenever possible. A fall in blood pressure was averted in a majority of instances by the use of 50 mg of ephedrine sulphate. Half of this amount was administered hypodermically about 20 minutes before operation and the remainder immediately before the spinal anesthetic was injected. In patients under 15 years of age, open drop ether was usually employed. In certain patients with marked hypertension or cardiac decompensation, local anesthesia was used.

Incision —Whenever the diagnosis of acute appendicitis was made the McBurney incision was used. If it did not afford sufficient exposure, it was unhesitatingly extended in any desired direction.

Operative Procedure —The appendix was removed regardless of its pathologic condition except in those instances where to do so would have destroyed the wall of a definite abscess and in one fatal case. Where an abscess was found against the lateral wall it was drained extraperitoneally whenever possible. The appendix was divided with the scalpel and the stump cauterized with phenol, ligated, and oversewed with linen.

Occasionally in patients in whom there was marked induration in the cecal wall, a rubber catheter was introduced through the stump and the cecum closed around it as advocated by DoHance.⁸ We believe that it is of the greatest importance that the small bowel be kept out of the operative field except the terminal few inches of ileum. It was possible, as a rule, to do this through the McBurney incision and we believe that this is one advantage of this approach.

Drainage —Fibrinoplastic exudate on surfaces other than the appendix itself, gross fecal contamination, and frank pus were regarded as sufficient indications for drainage. Free fluid was regarded as an indication only when it appeared to be definitely purulent. A few patients in whom the attachments of the appendix were extensive and fatty, and in whom numerous ligatures were necessary, were drained in the absence of other indications. As a rule the younger men drained some patients in order to be on the safe side, where men with more experience might not have done so.

When widespread peritonitis was present and the local exudate extensive, the appendiceal site was usually drained with iodoform packing covered with a sheet of rubber dam, the lateral colic gutter with a cigarette and the pelvis with a soft rubber tube or a cigarette and a tube. In such cases the wound was closed loosely. Hernia resulted in a certain percentage of such patients but we do not believe that this consideration should weigh in the surgeon's mind in planning the treatment of widespread peritonitis. The advantage of the gauze packing is that it prevents the small bowel from falling back into a heavily contaminated field. The object of drainage in the lateral colic gutter and in the pelvis is the prevention of secondary abscesses. The rubber dam covering the gauze is used to prevent adhesions to the gauze.

The principal objection to the use of drainage is the frequency of intestinal obstruction due to the development of adhesions. In this series, postoperative

obstruction necessitated ileostomy in eight cases up to 1933. In that year suction drainage of the gastro-intestinal tract was instituted in all patients with extensive peritonitis with the result that only one ileostomy has been carried out since. This was due to paralytic ileus and not to adhesions. We believe that suction drainage of the gastro-intestinal tract has made a definite contribution to the treatment of appendicitis with peritonitis and that the argument that drainage of the peritoneum should be minimized on account of the danger of obstruction has lost most of its validity. The McBurney incision undoubtedly facilitates maintenance of the drains against the lateral wall.

Postoperative Management—Confining the discussion to cases with moderate or widespread peritonitis, postoperative care was planned with a view to affording physiologic rest to the intra-abdominal viscera. Nothing was given by mouth or by rectum. Suction drainage was used prophylactically to decompress the upper gastro-intestinal tract. The use of prostigmine and pitressin was avoided if possible and these drugs were never resorted to during the first three days after operation. The only possible breach of the principle of putting the intestine at rest was the routine administration of morphine sulphate, which, according to the observations of Abbott and Pendergrass⁹ and of Puestow,¹⁰ may increase the motility of the small intestine. The use of morphine sulphate is defended on empiric grounds alone. Its value has been agreed upon by a number of clinicians of extensive experience. When given regularly and when suction therapy is also used, distention seldom appears. In elderly people the danger of respiratory depression must, of course, be weighed against the advantages offered by the use of morphine sulphate and a compromise reached.

Fluids were given intravenously by the continuous drip method. In all severe cases sulfanilamide was administered by hypodermoclysis. Substantial quantities of physiologic saline solution were needed for this and had to be reckoned in the total intake. The fluid given by vein contained 5 per cent glucose and usually half of it also contained 9.0 Gm. of sodium chloride per liter. In adults the total fluid intake was about 4,000 cc. the first 24 hours and about 3,000 cc. each succeeding 24 hours until the patient was clearly recovering. Serum chlorides and serum protein concentrations were determined every 48 to 72 hours and served as guides in the administration of saline.

Transfusions of citrated blood were often given in cases of anemia, hypoproteinemia and in patients with rapid pulse rate and peripheral vasoconstriction.

Sulfanilamide Therapy—Indications Sulfanilamide is now being used in all cases that have been drained and in an occasional borderline case in which a rapidly advancing process has been found at operation but in which operation has been performed before the usual indications for drainage have appeared.

It is also being employed preoperatively as an adjunct to the delayed method of treatment and to protect the patient from peritoneal spread in ap-

pendiceal abscess where transperitoneal drainage may be necessary. It was used in about 40 per cent of the cases since the latter part of 1936.

Method of Administration—In patients with spreading peritonitis in which the limits of the peritonitis extended beyond the operative field, sulfanilamide is now given in 0.8 per cent concentration in physiologic saline solution by hypodermoclysis. The dosage is usually 8 Gm. the first day and is reduced about 1 Gm. a day, the amount being varied to some extent according to the response of the patient. In patients with milder infections the usual dose is 6 Gm. the first day by mouth. This is gradually reduced to 3 Gm. over a period of four to seven days and then stopped. We have not attempted to adhere to a rigid dosage schedule but cite these figures as representative of our current practice. Each day's dose is given in four installments at six-hour intervals. The blood concentration of sulfanilamide should be maintained above 5 mg. per cent and we have kept it above 15 mg. per cent in certain cases.

Complete blood counts should be made every 24 to 48 hours. If rapid anemia or leukopenia develops, the administration of the drug may have to be discontinued.

Duration of Intensive Treatment—The decision to start fluids by mouth rested on the occurrence of audible peristalsis or the passage of flatus, a fall in temperature lasting 24 hours, abdominal relaxation on the left side, and a fall in pulse rate. With the appearance of these favorable signs suction drainage was discontinued and venoclysis stopped after the oral intake of fluids had been increased to 1,500 cc. per day.

Sulfanilamide was seldom stopped before the fifth day and often not before the seventh. Occasionally unfavorable reactions made it necessary to stop it sooner.

Sulfanilamide Reactions—Reactions to the drug when given by hypodermoclysis are not different from those seen after oral administration. Cyanosis has been usual and should, as a rule, cause no alarm. In the very sick patient it should not be confused with the cyanosis of a failing circulation. Hyperpyrexia with or without tachycardia or leukocytosis has been the most frequent toxic manifestation. The drug-fever seldom came on before the fourth day unless the patient had previously had sulfanilamide. It must be differentiated from an exacerbation of the disease by the lack of local signs. We regard it as sufficient reason to stop the drug in a patient who is convalescing satisfactorily. The fever may persist for two to three days after the drug is stopped. We have had no fatal reactions. Reactions of all kinds have been decreased by gradually reducing the dose and stopping the drug in five to seven days whenever possible.

Some of the hemolytic *Streptococcic* infections in which sulfanilamide was first employed showed a marked tendency to relapse. It has been our experience that, peritoneal infections once overcome, as indicated by a fall of pulse rate and temperature, the passage of flatus by rectum and localization

* Crystalline sulfanilamide for this purpose was kindly supplied in sterile ampules by Merck and Co.

or disappearance of abdominal signs seldom flare up unless there is gross mishandling such as premature catharsis, too early disturbance of drains, etc. There have been no untoward reactions at the site of injection and the pain occasioned has not been more than is usually experienced with hypodermoclysis of normal saline solution alone.

Discussion—The management of spreading peritoneal infections associated with acute appendicitis remains of interest because of the maintained high mortality attending this complication. Education of the laity and our medical students and practitioners in the necessity for early diagnosis and early operation has and will result in a reduction in the incidence of spreading peritonitis and, therefore, a lowering of the mortality of acute appendiceal disease, but spreading peritoneal infection will probably never be eradicated. Some years ago the late A. P. C. Ashhurst stated "There is no problem of acute appendicitis, the problems of appendicitis are the problems of its complications." We are in agreement with this statement.

We do not believe that much can be gained by attempting to classify cases into local, spreading and general peritonitis. Local peritonitis from a perforation near the base may, in a few hours, become a very widespread infection, and general peritonitis is, in our opinion, an autopsy rather than a clinical diagnosis. Surely the operator should not attempt to verify this diagnosis, because, of necessity, this would involve extensive exposure and manipulation of the bowel. The difficulties of differentiating spreading from so-called "general peritonitis" are many, and too often the most experienced clinician cannot state just how far the process has extended. The infection may be widespread a few hours after the onset of pain and it still may be localized many hours after the beginning of symptoms. We, therefore, do not believe that operability should be determined by the time elapsed from the onset of symptoms to the time of admission to a hospital.

The most important problem in acute appendicitis is infection. Infection of the peritoneum may be present before rupture of the appendix, for gangrene or acute diffuse suppurative lesions may permit organisms to pass into the free peritoneal cavity. The difference between this type of peritonitis and that associated with perforation is one of degree, in the latter, gross soiling is more apt to be present.

While there is no universal agreement among authors as to the bacteriology of appendiceal peritonitis, it is generally believed that the colon group is the most common invader of the peritoneum in this condition. It is our opinion that when these findings are not confirmed in any one institution something is wrong with the bacteriologic study. *Streptococci* are frequently present. Some of these are aerobes, some anaerobes, and some are facultative anaerobes. Some of the *Streptococci* are hemolytic while others are not. Anaerobes of the Welch type are also found, but there is a difference of opinion as to the frequency of their presence in the peritoneal exudate following perforation of the appendix. Meleney and his associates¹¹ found them in 20 per cent of their cases, Altemeier¹² in but 10 per cent, while Bower¹³ states "The *Clostridium welchii* was present in 60 per cent of instances in the flora

of spreading peritonitis in man and dog." A study of the data of the same author presented elsewhere¹⁴ discloses the fact that the *Clostridium welchii* was found in but 38.2 per cent of a total of 55 cases studied. Only 35 of the total group showed anaerobes, and it was 60 per cent of this number, or 21, which had present the *Clostridium welchii*.

The decrease in the mortality of puerperal sepsis resulting from the use of sulfanilamide, which was demonstrated by Colebrook,⁶ suggested that chemotherapy might provide a means of treatment of considerable usefulness in spreading peritonitis resulting from acute appendicitis. The administration of the drug was begun immediately after operation, because Buttle, Gray and Stephenson¹⁶ had shown that the value of sulfanilamide in the treatment of hemolytic *Streptococcus* infections in the mouse was increased by the early use of the drug.

In the early cases in the series the drug was discontinued in 48 to 72 hours when the culture failed to show hemolytic *Streptococci*. The demonstrated effectiveness of sulfanilamide against the *Escherichia coli*¹ soon caused us to use the drug when this organism was present, and before long it was employed routinely in all cases regardless of the culture report.

The method of administration we finally developed was based upon the observation which one of us had made (J. S. L.) that the blood level was more constantly maintained when the drug was repeatedly administered at relatively short intervals than when larger doses were given at infrequent intervals.

One of us (J. S. L.¹⁸) believes that the gross pathologic characteristics of the lesion are often of more importance in determining the effectiveness of the drug than is the species of the infecting organism. Infections characterized by the rapid invasion of contiguous structures, and associated with a minimal degree of necrosis, respond more favorably than do infections in which there is also considerable tissue injury and necrosis, or where the infection is confined to a local abscess.

The peritoneum is an area where infections can, and under favorable conditions do, advance rapidly. The peritoneal surfaces are richly supplied with blood vessels so that even in fatal cases it is rare to find serosal ulceration or gangrene of the tissues except in the area of primary infection. Since transudation is known to occur into the peritoneal cleft, it was of interest to determine whether sulfanilamide passed from the blood into the peritoneal transudate or exudate. In the dog receiving sulfanilamide we have found that the drug passes rapidly into fluid injected into the peritoneal cavity.

Three dogs previously anesthetized with sodium amytal were given intraperitoneal injections of physiologic saline solution one hour after receiving a sulfanilamide solution by hypodermoclysis. One-half hour later a sample of peritoneal fluid was aspirated and the sulfanilamide concentration determined. Blood samples were taken before fluid was injected intraperitoneally and after the sample was taken. Even in this short time the level in the peritoneum had risen to nearly one-half of the blood level. Under these artificial conditions fluid is rapidly leaving the peritoneal cavity, whereas under the conditions of peritonitis fluid is being poured into the peritoneum. It is, therefore,

probable that the sulfanilamide concentration in the peritoneal cavity under the actual conditions of its therapeutic use is closer to the blood level than under the conditions of the experiment summarized in Table II

TABLE II
CONCENTRATION OF SULFANILAMIDE IN PERITONEAL FLUID AFTER
SUBCUTANEOUS ADMINISTRATION

Dog No	Weight Kg	Sulfanilamide Injected Subcutaneously Mg per Kg	Physiological Saline Solution Injected Intraperitoneally Cc	Concentration of Sulfanilamide in Blood			Concentration of Sulfanilamide in Peritoneal Fluid	
				Before* Mg Per Cent	After† Mg Per Cent	Average Mg Per Cent	Peritoneal Fluid Mg Per Cent	Percentage of Mean Blood Level
916	6 6	48	300	2 5	3 6	3 0	1 3	43 0
917	7 7	64	300	5 5	5 7	5 6	2 2	39 3
918	7 0	80	300	5 8	6 2	6 0	2 5	41 6

* The first determination of the blood sulfanilamide concentration was made one hour after subcutaneous injection of the drug. Immediately after this sample was obtained, the intraperitoneal injection of saline was administered and 30 minutes later a sample of the peritoneal fluid was withdrawn.

† After the peritoneal fluid was withdrawn, the second blood sample was obtained.

The gangrenous appendix cannot be considered as a favorable site for the action of sulfanilamide, and there is no adequate reason to believe that good results would follow sulfanilamide treatment without operation.

We do not believe that anything is to be gained by inserting drains into the peritoneum and leaving the ruptured appendix behind. Drainage of a widespread area of infection is not obtained and much is lost by permitting the source of infection to remain behind. That some of the very late cases of spreading infection stand their best chances of recovery by the delayed, or Ochsner, method of treatment cannot be denied, but increasing experience has led us to believe that these cases are by far in the minority and that many of the patients now being treated by the delayed method should be subjected to immediate operation.

It is not certain that the *Clostridium welchii* plays an important rôle in appendiceal peritonitis. A trial of perfringens antitoxin in appendiceal peritonitis did not lower the mortality in the hands of the senior author. The recent favorable report of Bower¹⁹ on the treatment of appendiceal peritonitis in the dog with sulfanilamide is of interest in this connection, especially as Bower has been an advocate of the anti-Welch serum.

We do not believe that the mortality of spreading peritoneal infection can be materially affected by the use of any serums now available. For the two most common invaders, the colon bacillus and *Streptococcus*, no potent serum

is available. There is considerable difference of opinion as to whether the *Clostridium welchii* is saprophytic or pathogenic in appendiceal peritonitis. In our opinion it is not the major cause of death.

CONCLUSIONS

(1) The mortality in a series of 809 consecutive cases of acute appendicitis has been reduced from 15 per cent in the first 552 cases to 0.4 per cent in the last 257 cases. The improvement is, we believe, the result of the employment of sulfanilamide in all severe cases in the latter group. No other known factor was changed.

(2) A number of patients with very extensive peritoneal infection secondary to appendicitis have recovered with much less reaction than would have been predicted on the basis of experience with the first 552 cases.

(3) Sulfanilamide readily diffuses into peritoneal fluid in the experimental animal. All the available evidence indicates that the peritoneum is a favorable site for the action of sulfanilamide.

(4) In view of the fact that appendiceal peritonitis is nonspecific, the improvement in mortality and in the course of the disease obtained with sulfanilamide is in agreement with the concept of one of us (J. S. L.) that the character of the lesion is more important than the specificity of the organism in determining the effectiveness of the drug.

(5) Attention is also called to the fact that in this series no cases of intestinal obstruction due to adhesions have been encountered since the use of suction drainage of the stomach.

REFERENCES

- ¹ Kelly, F. R., and Watkins, R. M. JAMA, 112, 1785, 1939
- ² Editorial, JAMA, 112, 2066, 1939
- ³ Bower, J. O. JAMA, 99, 1765, 1932
- ⁴ Domagk, G. Deutsch. med. Wchnschr., 61, 250, 1935
- ⁵ Colebrook, L. C. Lancet, 2, 1237, 1937
- ⁶ Colebrook, L. C. Lancet, 2, 1291, 1937
- ⁷ Wangensteen, O. H., and Paine, J. R. JAMA, 101, 1532, 1933
- ⁸ Dorrance, G. M., and Nealon, S. W., Jr. New York State Jour. Med., 35, 119, 1935
- ⁹ Abbott, W. O., and Pendergrass, E. P. Am. J. Roentgenol., 35, 289, 1936
- ¹⁰ Puestow, C. B. Surg., Gynec. and Obstet., 68, 121, 1939
- ¹¹ Meleney, F. L., Harvey, H. D., and Yayoseff-Jern, H. Arch. Surg., 22, 1, 1931
- ¹² Altemeier, W. A. ANNALS OF SURGERY, 187, 517, 1938
- ¹³ Bower, J. O., Burns, J. C., and Mengle. Surgery, 3, 645, 1938
- ¹⁴ Bower, J. O., Burns, J. C., and Mengle, H. A. Surg., Gynec. and Obstet., 66, 947, 1938
- ¹⁵ Bower, J. O. JAMA, 99, 1765, 1932
- ¹⁶ Buttle, G. A. H., Gray, W. H., and Stephenson, D. Lancet, 1, 1286, 1936
- ¹⁷ Helmholtz, H. F. Jour. Pediat., 11, 243, 1937
- ¹⁸ Lockwood, J. S., Coburn, A. F., and Stokinger, H. E. JAMA, 111, 2259, 1938
- ¹⁹ Bower, J. O., Burns, J. C., and Mengle, H. A. Jour. Lab. and Clin. Med., 24, 240, 1938

THE MIKULICZ PROCEDURE *

WITH SPECIAL REFERENCE TO THE LATE RESULTS IN THE MANAGEMENT
OF CARCINOMA OF THE COLON

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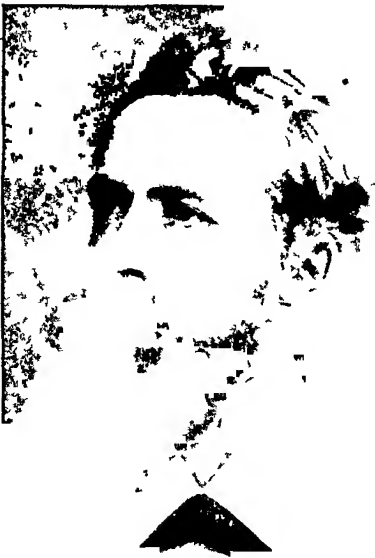
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ALTHOUGH successful removal of a portion of the colon for carcinoma was accomplished more than a century ago, and reported several years later,⁴² there is still great difference of opinion as to the best method of performing such a resection. Many advocate and perform "primary resection and suture" in the average case,^{10, 24} while others strongly urge the use of stage operations such as that sequence ordinarily known as the Mikulicz procedure. It was



Johannes Mikulicz in 1878

with some hesitation that we selected such a controversial subject, recalling a discussion before this Society, just one year ago, during which the Mikulicz operation was described in very uncomplimentary terms.⁸ Our excuse for reopening the argument lies in the dearth of material to be found in the literature in regard to the *late* results that may be obtained with the Mikulicz plan in the surgical attack upon carcinomata of the large bowel. Much has been written about its relative safety, about many major and minor modifications, new types of clamps, and morbidity, but little has been written about what eventually becomes of these patients. After all, when dealing with cancer, one cannot approach the problem

timidly. Surgical safety is highly important, but thoroughness in removal and efficiency in cure are even more important. At the Roosevelt Hospital we have long been partial to the Mikulicz procedure, as the operation of choice in the average case. We have been anxious to find out if the late results obtained justify its continued application. A careful review of our records has been made from this point of view.

When Mikulicz came to this country, in 1903, to address the American Surgical Society,²⁹ he operated in the Syms amphitheater of the Roosevelt Hospital. He was the guest of Dr. George Brewer, who assisted him at the

* Read before the New York Surgical Society, January 11, 1939. Submitted for publication December 16, 1938.

operation. He wore white cotton gloves, changing them perhaps a dozen times during the course of the operation. Those present were much impressed by his technical skill. The following year Doctor Brewer spent five days with Mikulicz in Breslau.⁵ A few weeks ago one of us (H. P.) talked with Doctor Brewer, and his description of the work in Mikulicz's clinic was most interesting. He had been greatly impressed by Mikulicz's operative skill, and by the very warm personal interest he took in his patients. At a time when many of the leading European surgeons seemed to be more interested in the specimen than the patient, Doctor Brewer found Mikulicz a great exception. It was only about one year later that Mikulicz went to Vienna to be operated upon by Doctor von Eiselsberg, who found the situation entirely hopeless.

It would seem appropriate to briefly run over some of the main features of the so-called Mikulicz plan, before proceeding to the consideration of the late results. For our purposes, this term may be applied to any operation, performed in stages, that involves mobilization, the fashioning of a "double-barreled shotgun" out of the afferent and efferent loops, the prompt or delayed resection of the growth outside the peritoneal cavity, and the subsequent removal of the partition by the necrosing pressure of a clamp. Innumerable modifications have been described, but the principle remains the same. The name of Bloch³ or Paul^{33, 34} might have been applied to the operation with at least equal justification. Mikulicz did not claim originality. As a matter of fact, he pointed out²⁸ that a similar type of operation had been performed as early as "the 1870's" by several surgeons (Maydl,²⁵ Schede,⁴⁵ *etc.*). The early operations of Mikulicz involved the removal of the tumor itself, with but little margin of normal bowel and scant attention to the mesentery. However, his later operations were much more radical. This is obvious from a review of his section in the "Surgical System" edited, in 1904, by Bull,² which urges a margin of "three to five centimeters" of normal bowel on each side of the growth, and extensive resection of the adjacent mesentery.

Paul practiced the immediate removal of the exteriorized growth, with insertion of flanged glass tubes into the ends of the bowel. In his earlier report,³³ only two of seven resections were multiple-stage procedures, but subsequently he reported two other interesting cases in which he had adopted this plan.³⁴ Rankin has popularized and perfected the "obstructive resection,"^{37, 38, 39, 40} preceded by cecostomy or colostomy if the element of obstruction is a prominent one. However, this is, in principle, the old Mikulicz plan, and stands out in marked contrast to resection with anastomosis.

Although differences in caliber, fecal content, blood supply, lymphatics, and mobility raise varying problems in different portions of the large bowel, the Mikulicz principle has been applied to all parts of it. Lahey²² has adopted it as his usual method of handling growths of the right side of the colon, as well as the left. Rayner,⁴¹ and others, have had similar good results in applying this plan to resections of the right colon. The ileal contents are carried

off by a tube for a few days, and the subsequent temporary ileal fistula has not proved to be the great nuisance that one would expect

Growths of the transverse colon are well adapted to management by the multiple-stage method, those situated near the flexures being adequately mobilized without much difficulty. The limbs may have to be twisted slightly as they emerge from the longitudinal incision, but this usually gives no trouble. Hartwell,¹⁹ in his careful analysis of the special group of splenic flexure growths, urged the use of multiple-stage resections, the mortality in one-stage resections being three times higher.

The sigmoid, commonest site of cancer of the colon (exclusive of the rectum), presents the ideal site for the employment of the Mikulicz procedure. Unless the mesentery is extraordinarily short, or the abdominal wall extremely thick, adequate mobilization at this site is easy. One of Paul's¹⁴ early cases, operated upon under very difficult circumstances, was of this physical type. By an ingenious use of his flanged tubes, he performed a successful resection and was able to report the patient as alive and well two years later. As a matter of fact, one can occasionally "exteriorize" a carcinoma of the upper rectosigmoid, although they may have been resigned before operation to performing a complete abdomino-perineal resection. Thorough mobilization, depression of the parietal peritoneal level, and the use of iodoform gauze packing to form a bed for the growth until the second stage, will sometimes allow the application of the Mikulicz plan in these cases and the avoidance of a permanent artificial anus. It is in this group that spontaneous closure of the fecal fistula is most likely to occur. W. J. Mayo²⁷ urged the more frequent resort to this method, in low sigmoid and high rectosigmoid growths, more than 25 years ago.

The use of a "perineal Mikulicz," for low rectosigmoid growths, has been applied to occasional cases. There were none of these in the Roosevelt Hospital series. Geister¹⁸ presented such cases before this Society in 1931 and again in 1936, and referred to Kuttner's cases. Carter⁹ has performed several such operations with encouraging results.

The actual choice of operation in a given case of carcinoma of the colon must be predicated upon four general considerations—the condition of the patient, the experience of the surgeon, the site of the growth, and the type and degree of complications. Most observers agree that the Mikulicz plan is the safest way in which one can remove portions of the colon. Ample statistical support of this belief is available, and (based upon such reports as those of Mikulicz,²⁸ Rayner,⁴¹ Moszkowicz,³⁰ Rotter,⁴³ Bolling,⁴ Anschutz,¹ Dixon,¹¹ Oppel,³² *etc.*) one can state, in general, that primary resection and anastomosis carries a mortality of 20 to 35 per cent, while the Mikulicz procedure, properly applied, entails a mortality of 10 to 20 per cent. Mikulicz's own mortality was 12.5 per cent. Rankin³⁷ has lowered this figure to less than 10 per cent, and has reported a series of 31 consecutive cases with only one death. It is obvious, of course, that if the multiple-stage method be re-

served for the "bad-risk" cases that are too old or too sick to stand primary resection, such low mortality figures would be impossible.

It is generally agreed that acute obstruction calls for preliminary cecostomy or colostomy, no matter what type of resection is to follow. It is a factor that is present in about 30 to 40 per cent of cases of colon carcinoma, as they come to the surgeon. Anschutz¹ noted obstruction of considerable degree in 51 cases out of 128, Brown,⁶ in 43 of 171, Mikulicz,²⁸ in 28 of 111 cases. Nearly half of the patients in the Roosevelt Hospital series showed some obstruction, and Haitwell¹⁹ noted that, in the special group of splenic flexure growths, nearly three-fourths presented acute obstruction at the time of operation. In 27 per cent of the cases in our series, a preliminary cecostomy was performed. Formerly, the use of the first-stage Mikulicz operation, with immediate decompression of the upper loop by means of a catheter, was often tried in these cases. It was far from satisfactory. One must remember that the mere handling of obstructed, edematous bowel may lead to peritonitis, even in the absence of gross soiling. Cecostomy works well as an emergency vent, but it certainly does not really divert the fecal stream, nor does it afford the opportunity for rest and cleansing of the bowel distal to it that one gets with a divided colostomy such as Cheever¹⁰ and Sistrunk⁴⁶ have urged, preferably in the right half of the transverse colon.

Critics of the Mikulicz operation point, with considerable justification, to the long morbidity, the necessity of multiple operations, the nuisance of a fecal fistula for several weeks, the likelihood of hernia, and the possibly "inadequate" removal of the lymphatic-bearing area adjacent to the growth. It has been noted that recurrence in the abdominal wound itself may occur. Rankin reported a definite incidence of these when using the "original" Mikulicz type operation, this being one of the main reasons for his modified plan which involves the removal of the growth at the primary operation.³⁷ Whipple⁴⁸ has also spoken of this possibility. There have been no recurrences in the abdominal wall in any of our cases, so far as we have been able to determine.

Possible contraindications to the Mikulicz exteriorization, as enumerated by Sistrunk⁴⁶ and endorsed by Rankin,³⁹ are to be found in the presence of adherent growths with infection of the wall of the bowel and adjacent tissues, large growths associated with infection, a considerable degree of obstruction, or occasionally in obese patients with short mesenteries. Great care and patience can often enable one to mobilize growths such as are mentioned as the fourth class above. However, traction on such mesenteries is hazardous, and in this group occur most of the cases of subsequent fatal embolism. The first three groups mentioned above as "contraindications" can often be transferred to the operable group by preliminary cecostomy or transverse colostomy. However, cure by resection after a colonic carcinoma has perforated (with abscess formation) is very rare, although it does occur.²⁰

It is true that the adoption of the Mikulicz plan means multiple operations and a long hospitalization. We feel however that the advocates of primary resection and anastomosis are misleading in this regard. They seem to urge

that the somewhat increased mortality is more than offset by the assurance of a single operation with prompt healing. This is, however, not always the result, by any means. Of the large series reported by Cheever,¹⁰ only 50 per cent of the primary suture cases were completely healed at the time of discharge. Twenty-seven per cent had fistulae, and the other 23 per cent had granulating wounds. The average hospital stay was 43.3 days. Of the Mikulicz cases in the same report, only 30.7 per cent were completely healed at the time of discharge, and the average hospital stay was 53 days. Among Rayner's⁴¹ primary resection cases, performed with a very low mortality, there were "several" cases of wound suppuration and of fecal fistulae. It is evident, therefore, that primary suture does not avoid complications in wound healing in a considerable percentage of cases.

As to the "wideness" of the removal of bowel and mesentery, one must be practical. The two prime factors in cure are early operative intervention and a relatively benign growth, the latter factor being the more important of the two. All surgeons of experience have seen, on the one hand, very small primary colon carcinomata with the liver full of metastases, and on the other hand, huge extensive tumors that do not recur after operation. A high percentage of excised, enlarged regional lymph nodes in these cases prove, on examination, to be inflammatory. While one must always lean toward radicalism and thoroughness in all cancer surgery, it is doubtful if many cases of cancer of the colon are saved by unusually wide excision of mesentery who would not have been saved by resection of the growth itself, with reasonably adequate margins all around. At any rate, one can certainly perform almost as radical a resection with the multiple-stage operation as in the one-stage resection. Rankin³⁹ has outlined the method of accomplishing this.

The case for primary resection and anastomosis has been admirably presented by MacFee,²⁴ who uses the simple but effective end-to-end aseptic anastomosis described by Scarff,⁴⁴ and reports a very low mortality (16.1 per cent). The whole problem is reviewed and thoroughly discussed, but little is said about late results. The dangers of primary resection and suture of the large intestine were well stated in the "Surgery" edited by Bull² some 35 years ago. The same anatomic, technical, and bacteriologic considerations seem to us to be still valid. It is a vastly different problem from anastomosis of the small intestine. We think it highly important to realize that among those surgeons who urge the multiple-stage procedures, with all their inconveniences, are many men of vast experience and great technical skill, in whose hands primary anastomosis should be as safe as is possible.^{22 37 26 27, 11}

It might be well to briefly consider the routine that we employ in multiple-stage resections, before taking up the question of the late results. In the presence of obstruction, preliminary cecostomy is always performed. Unless the patient is in a very precarious condition, exploration is carried out at this time. If one is very gentle, a complete exploration can be made without unduly increasing the risk, and it enables one to take inventory and plan intelligently as to the proper future course. The first stage of the resection

follows in 10 to 15 days. Meanwhile, with subsidence of edema, the growth has usually "opened up," with the passage of material by rectum.

At the time of the first stage of the Mikulicz resection, one must employ a really adequate incision. If previous exploration has not been made, it is carefully performed in a regular sequence—examining the liver and aortic nodes first, and the growth itself last, for one may encounter a small abscess when least expected. If the growth is found to be removable (and this should be done at times, even in the presence of liver metastases), a painstaking mobilization is performed, "freeing-up" the tumor and the adjacent mesentery down to its root. This may necessitate the division of the splenocolic ligament, even when the growth is rather remote from it, for this will give much more mobility. The two limbs of bowel, as they approach and leave the growth, are then approximated and sutured together with interrupted silk sutures. A longitudinal band is selected as the site for the suturing, and two rows are often placed, slightly more than one-half inch apart. The two limbs should be approximated for a distance of at least two and one-half inches below the level of the peritoneum, and preferably more. In the presence of a functioning cecostomy, the "obstructive resection" of Rankin may be performed, with immediate removal of the growth. However, in the usual case, we still do the old-fashioned exteriorization, using iodoform gauze as a bed for the growth, if it tends to come in contact with the wound. At the time of the first-stage Mikulicz operation every patient, without exception, receives a transfusion of at least 500 cc of blood, usually during the latter part of the operation or as soon as it is completed.

The growth is removed by cautery after 48 to 72 hours. Many surgeons remove it earlier, but this lessens the safety of the operation, due to the danger of peritonitis from inadequate sealing. For the same reason, we never take sutures in the bowel wall, in order to anchor it to the peritoneum at the time of the first stage. The peritoneum is closed snugly around the limbs as they are brought out, and we often include a small epiploic appendage in the peritoneal sutures as they are tied, but we feel that it is dangerous to sew the bowel wall directly to the parietal peritoneum.

In dividing the partition between the two sides of the "double-barreled shotgun" that has been constructed, we usually use a large Kocher clamp, having found that to be the most satisfactory in the long run. Now that they are made out of much lighter-weight metals, the newer type clamps¹⁴ are probably more desirable. The clamp is applied as soon as the growth is removed, and it should necrose the "spur" and cut through in six or eight days. It is ordinarily tightened every other day. If care is taken in its application, after careful palpation through the bowel openings, injury to small intestinal loops or to the blood supply is unlikely. It is absolutely essential that the partition be cut down deeply, even if this requires a second or even a third application of the clamp. This is tedious and annoying for the patient, but will prove very worthwhile. Rankin states that if the spur is cut down properly, "more than half" of the fecal fistulae will close spontaneously. We

have not been so fortunate, only 10 of our 51 operative survivals having had spontaneous complete closure. It is likely that we have not always waited long enough. Among the earlier cases, there were many in which closure was attempted much too soon, within 15 days of the resection. This led to many failures in closure. If the closure is delayed for four to six weeks or longer, it is usually easy to perform and much more apt to be successful. There is often some discharge of gas and fecal matter (in 21 of 37 of our cases) after closure, but this soon clears up, and reclosure is rarely necessary. We have recently found the Furniss¹⁵ clamp a very useful aid in closing these colostomies. Ordinarily, it is not necessary to open the peritoneum, but if this is done it is of little consequence, on account of the marked immunity that these patients have developed. One must always remember that these patients are prone to develop incisional herniae, and it is at this final stage operation that one can guard against this by careful dissection and adequate closure of the layers. This is another good reason for not attempting closure too soon, while the tissues are still edematous. In many of our later cases, the patients have been sent home for a few weeks before returning for closure.

Late Results—The late results in the surgery of cancer of the colon are far more encouraging than they were at the start of the century, although, as MacFee²⁴ has pointed out, most of the cases are still of long standing when they reach the surgeon. Raiford,¹⁶ reporting from the Johns Hopkins Hospital, found that in the period from 1900 to 1905, less than 25 per cent of the cases were operable, the operative mortality was 31 per cent, and only 14.6 per cent of the resected cases could be called five-year cures. From 1925 to 1930, 66 per cent of the cases were found to be operable, with a mortality of 17.3 per cent, and five-year cures in 28 per cent of the resected cases. Cheever¹⁰ found that 85 out of 154 cases were suitable for resection, and MacFee²⁴ reported that 49 per cent of the colon carcinomata admitted to the New York Hospital could be removed.

The curability of colonic cancer is one of the more hopeful aspects of cancer surgery. Late recurrences are rare, and it is highly probable that a patient who seems perfectly well three years after resection will have no recurrence. Anschutz reported 10 patients who died of recurrence following multiple-stage resection, and none of them lived more than 15 months. Of Mikulicz's cases, only one who died of recurrence could be classed as "late." This patient lived five and one-half years after operation, and is the only case of late recurrence that we have been able to find after a fairly complete review of the literature. This feature offers a marked contrast to many other fields of cancer surgery, with their disheartening late recurrences.

Late results are difficult to find in the literature, but a careful search reveals some very encouraging statistics. W. J. Mayo²⁷ reported that, of 262 resections of the large intestine for carcinoma, there were 54 per cent of five-year cures among those who survived operation. Most of these were Mikulicz type operations, this operation having been introduced into the Clinic

by C H Mayo about 1904, and adopted as the routine method of handling left-sided colon growths

After summarizing the reports of Hochenegg,²⁰ Anschutz,¹ Petermann,³⁵ Moszkowicz³⁰ and Mikulicz,^{28, 29} one finds that, of 79 operative survivals, 20 patients were known to be dead of recurrence, 36 were known to be living and well, of whom 23 had lived more than three years, 19 more than four years, and 10 more than five years. Many of the other patients in the group could not be traced, and the statistics are, therefore, far from satisfactory.

Radicalism, in one's approach to colonic cancers, is fully justified by experience. Resection of adherent small bowel, or stomach, along with the primary growth, has often been followed by five-year cures, and apparently hopelessly inoperable growths may be successfully removed. When a surgeon's operative mortality in colon resections is very low, it is likely that he has not been attempting the radical cure of certain cases of borderline operability that should be given this chance, notwithstanding the increased risk involved.

We have reviewed the Mikulicz operations for carcinoma of the colon at the Roosevelt Hospital, and the present report is based on a survey of the records of 70 cases in which a carcinoma of the large bowel was resected by the Mikulicz method. Seven of these cases were deleted from the statistical survey, with what we consider adequate justification, as being in no sense a true "test" of the operation. One case had large coexisting carcinomata of the cecum and the sigmoid, the latter being handled by the Mikulicz plan. One patient presented a sudden perforation of a large growth with fulminating, diffuse peritonitis, and another had a large sigmoid growth with perforation which resulted in a large abscess that penetrated into the bladder. The remaining four of the seven deleted cases represent heroic efforts to reclaim hopelessly inoperable situations, in which multiple resections involving adherent stomach, small bowel, spleen, *etc*, were performed in addition to an exteriorizing operation upon the primary growth. The deletion of these seven cases, which we felt could not serve as a basis for determining the efficiency of the procedure, left a total of 63 cases for study. There were two hepatic flexure growths, 11 in the transverse colon, seven at the splenic flexure, 10 in the descending colon, 29 in the sigmoid, and four in the rectosigmoid.

Mortality—There were 12 deaths, an operative mortality of 19 per cent. There were three cases of fatal pulmonary emboli, three of cardiac failure (two of them very elderly), and one of "postoperative shock" (autopsy showed no adequate explanation). One death was ascribed to a virulent parotitis, and another was apparently due to novocain poisoning, death being sudden and unexpected while the patient was on the table. There were only two deaths due to peritonitis, one unexpected and one following the rupture of a large foul abscess during operation. The general condition of the patients seemed to represent the basis for most of the fatalities, as five of the cases were elderly, and 11 of the 12 had regional or liver metastases.

Operative Survival—There were thus 51 operative survivals and these

have been divided, in an attempt at clarity, into those operated upon more than three years ago, and those operated upon during the past three years. Although a longer period than three years would be desirable, experience has shown that a patient who is "recurrence-free" three years after resection of a colonic cancer is apparently likely to remain so.

A total of 37 of the cases surviving operation were operated upon more than three years ago. Fourteen of these are known to be living and 13 are apparently well, having been followed for an average of eight years since operation. The other patient has lived more than four years since the resection of a growth of the sigmoid, but now has a carcinoma in the posterior wall of the bladder. There is some difference of opinion as to its source, but we feel that it is very likely a recurrence, and are listing it as such.

Nine patients are known to have died with recurrence. Eight other patients were followed for a time and then "lost." Six of these we have considered as "dead of recurrence" in our survey. Two of them may fairly be listed as probable "cures," one having been followed seven years after operation and the other nearly three years. Both were well when last seen.

Six other patients are known to be dead, none of whom had recurrence of colonic carcinoma, and five of whom lived long enough to be considered "cured" by the operation. One died 17 years postoperatively of cardiac failure, one died at 80, five years after operation, and one died of pneumonia four years after operation, autopsy showing no sign of recurrence. Two patients died after three and one-half years had elapsed since operation, one of cerebral hemorrhage and another of primary carcinoma of the uterus. The sixth case died two years after resection, following a belated second attempt to close a small fecal fistula. Although no sign of carcinoma was found, this case was not followed long enough to be considered a probable "cure."

We feel that it is reasonable to assume that 20 of the 37 patients who survived operation were "cured" of their colonic carcinomata by the Mikulicz type of multiple-stage resection. This group, constituting 54 per cent, is made up of 13 living patients, free of recurrence for an average of eight years, two in the "lost" group who had been followed long enough to make recurrence very unlikely, and five patients who died of some entirely unrelated condition after they had lived an average of six and one-half years following operation.

Fourteen of the patients who survived resection were operated upon less than three years ago, and are thus of no value in the estimation of end-results. It is interesting and encouraging to note, however, that only two of the 14 cases are dead of carcinoma, and that the other 12 cases are living without sign of recurrence. Four of these cases are very recent, but eight cases have lived more than one year (an average of 15½ months) since operation.

CONCLUSIONS

The Mikulicz procedure is still the safest method of removing a portion of the large bowel.

In spite of all the disadvantages of the Mikulicz plan, with its multiple operations and long morbidity, we believe that it is the procedure of choice in the average resectable colonic cancer

With careful mobilization and proper technic, a sufficiently thorough removal may be accomplished with this method, and it affords the patient a maximum chance for permanent cure

Radicalism, in the attack on large, adherent growths of the colon, is justified by the results obtained

Whether the operation for the removal of a cancer of the colon is to be performed in one stage or in multiple stages, painstaking resection of the neighboring lymphatic-bearing area of the mesentery is an essential part of the procedure

Late recurrences of carcinoma of the colon are rare, and a three-year survival period is more indicative of permanent cure than is a five-year period in many other types of cancer

A group of 63 patients is presented from the Surgical Service of the Roosevelt Hospital, on whom multiple-stage resections were performed for carcinoma of the colon. There were 51 operative survivals, and 37 of the cases were operated upon more than three years ago. A critical review indicates that 20, or 54 per cent, of these cases were apparently cured by the Mikulicz type of resection

REFERENCES

- ¹ Anschutz, W. Beiträge zur Klinik des Dickdarmkrebses. Mitt. a. d. Grenzgeb. d. Med. u. Chir., 3, Suppl. Bnd., 488-682, 1907
- ² Bergmann, E. von, Bruns, P. von, and Mikulicz, J. von. A System of Practical Surgery, N. Y. and Phila., 4, 476-478, 1904
- ³ Bloch, O. Om extra-abdominal Behandling af Cancer intestinalis (rectum derfra undtaget), etc. Nordiskt Med. Ark., N. S., 2, Nos. 1 and 8, 1892
- ⁴ Bolling, R. W. Carcinoma of the Left Colon. Partial Colectomy by the Multiple Stage Extraperitoneal Method of Mikulicz. Surg. Clin. N. Amer., 9, 733-740, June, 1929
- ⁵ Brewer, George E. Personal communication
- ⁶ Brown, K. P. Carcinoma of the Colon, Its Incidence, Treatment, and End-Results. Edinburgh Med. Jour., 33, 10-18, 1926
- ⁷ Burt, C. V. The Modified Mikulicz Operation as Opposed to the One-Stage Procedure for Carcinoma of the Colon. New York State Jour. Med., 35, 1148-1152, 1935
- ⁸ Discussion of Dr. Carlucci's cases, N. Y. Surgical Society, December 8, 1937
- ⁹ Carter, R. F. Personal communication
- ¹⁰ Cheever, D. The Choice of Operation in Carcinoma of the Colon. Tr. Amer. Surg. Assn., 49, 291-302, 1931, also ANNALS OF SURGERY, 94, 705-716, 1931
- ¹¹ Dixon, C. F., and Priestly, J. T. Factors Which Decrease Risk in Operations on Colon and Rectum. Surg., Gynec., and Obstet., 57, 206-212, 1933
- ¹² Dowd, C. N. The Advantages of the Two-Stage Operation of Partial Colectomy. ANNALS OF SURGERY, 71, 155-162, 1920
- ¹³ Dowd, C. N. Technic of Partial Colectomy by the Mikulicz Two-Stage Method. ANNALS OF SURGERY, 72, 681-689, 1920
- ¹⁴ Findlay, F. M. An Improved Clamp for the Mikulicz Procedure. ANNALS OF SURGERY, 103, 471-473, 1936
- ¹⁵ Furniss, H. D. A New Method of Intestinal Anastomosis. Tr. Amer. Assn. Obstet., Gynec., and Abdom. Surg., 47, 26-31, 1934

- ¹⁰ Gehrels, E Der operative Verschluss des kunstlichen After's ohne Spornquetschung Arch f klin Chir, 117, 705-715, 1921
- ¹¹ Gehrels, E Colon Resection Calif and West Med, 33, 568-572, 1930
- ¹² Gerster, J A C (See discussion in footnotes), ANNALS OF SURGERY, 104, 244-247, 1936
- ¹³ Hartwell, J A Carcinoma of the Splenic Flexure of the Colon ANNALS OF SURGERY, 66, 339-361, September, 1917
- ¹⁴ Hochenegg, J Zur zweizeitigen Resektion der Kolonkarzinome Jahresber u Arb d II chir Klin zu Wien (1904-5), 332-334, 1906
- ¹⁵ Lahey, F H Carcinoma of the Colon Surg Clin N Amer, 11, 233-241, April, 1931
- ¹⁶ Lahey, F H Resection of the Right Colon and Anastomosis of the Ileum to the Colon After the Plan of Mikulicz Surg, Gynec, and Obstet, 54, 923-929, 1932
- ¹⁷ Lahey, F H, and Jordan, S M Cancer of the Colon New England Jour Med, 205, 1125-1131, 1932
- ¹⁸ MacFee, W F Resection with Aseptic End-to-End Anastomosis for Carcinoma of the Colon ANNALS OF SURGERY, 106, 701-714, October, 1937
- ¹⁹ Maydl, C Ein Beitrag zur Darmchirurgie Wien Med Presse, 24, 437, 1883
- ²⁰ Mayo, C H, and Walters, W The Two-Stage Mikulicz Operation for Cancer of the Sigmoid Surg, Gynec, and Obstet, 39, 1-4, 1924
- ²¹ Mayo, W J Radical Operations for the Cure of Cancer of the Second Half of the Large Intestine, Not Including the Rectum J A M A, 67, 1279-1284, October, 1916
- ²² Mikulicz, J Chirurgische Erfahrungen uber das Darmcarcinom Arch f klin Chir, 69, 28-47, 1903
- ²³ Mikulicz, J On Operation on Malignant Growths of the Large Intestine Tr Amer Surg Soc, 21, 132-134, 1903
- ²⁴ Moszkowicz, L Die Dickdarmresektion nach der Vorlagerungsmethode Arch f klin Chir, 116, 260-275, 1921
- ²⁵ Noehren, A H Resection of Mobile Portions of the Colon by the Mikulicz Method, With a Report of Five Successful Cases West Jour Surg, 43, 618-623, 1935
- ²⁶ Oppel, W A Principles of Operative Treatment of Diseases of the Large Intestine ANNALS OF SURGERY, 60, 409-439 October, 1914
- ²⁷ Paul, F T Colectomy Brit Med Jour, 1, 1136-1139, May 25, 1895
- ²⁸ Paul, F T Two Cases of Colectomy Brit Med Jour, 1, 245-247, 1900
- ²⁹ Petermann, J Erfahrungen und Erfolge bei der operativen Behandlung des Dickdarmkrebses Arch f klin Chir, 86, 53-131, 1908
- ³⁰ Raiford, T S Carcinoma of the Large Bowel Part I The Colon ANNALS OF SURGERY, 101, 863-885, 1935
- ³¹ Rankin, F W Resection and Obstruction of the Colon (Obstructive Resection) Surg, Gynec, and Obstet, 50, 594-598, 1930
- ³² Rankin, F W The Surgical Treatment of Carcinoma of the Colon Surg, Gynec, and Obstet, 53, 229-238, 1931
- ³³ Rankin, F W Surgical Aspects of Carcinoma of the Colon Bulletin of the N Y Acad of Med, 8, 389-402, June, 1932
- ³⁴ Rankin, F W Cancer of the Colon Notes on Its Surgical Treatment Surg, Gynec, and Obstet, 59, 410-414, 1934
- ³⁵ Rayner, H H The Treatment of Carcinoma of the Colon Lancet, 1, 136-140, 1936
- ³⁶ Reybard (de Lyon) Memoire sur une tumeur cancéreuse affectant l'S iliaque du colon, ablation de la tumeur et de l'intestin, reunion directe et immediate des deux bouts de cet organe Guérison Bull de L'Acad Royale de Med, 9, 1031, July, 1844
- ³⁷ Rotter, J Zur chirurgischen Behandlung der Colonicarcinome Arch f klin Chir, 102, 651-683, 1913
- ³⁸ Scarff, J E Aseptic End-to-End Suture of Intestine ANNALS OF SURGERY, 83, 490-495, 1926

⁴⁵ Schede Verhandl der Deutsch Gesellsch f Chir, 7, 126, 1878
⁴⁶ Sistrunk, W E The Mikulicz Operation for Resection of the Colon Its Advan-
tages and Dangers ANNALS OF SURGERY, 88, 597-606, 1928
⁴⁷ Gordon-Taylor, G, *et al* Discussion of the Factors Making for Safety in the Sur-
gery of the Colon and Rectum Proc Roy Soc Med, 23, 1214-1223, February,
1930
⁴⁸ Whipple, A O Personal communication

DISCUSSION—DR CHARLES L JANSSEN (New York) said that, with Doctor Olsen, he had recently made an analysis of the cases of carcinoma of the colon admitted to the Presbyterian Hospital from 1916 to date. The series cover 489 cases. Of these, 252 had radical operations, with a complete follow-up on about 95 per cent.

Although the principle of the multiple-stage resection is a sound one in Doctor Janssen's opinion, he said that he felt that the old-fashioned type of Mikulicz operation should be discarded. It is not fulfilling the requisite of a radical method of excision of malignant tumor, because the lymph nodes which can, without greater risk, be removed are left in. Therefore, for five years he has favored a modified technic of the Rankin type. He felt that with due respect to Mikulicz, the use of his name could be discontinued on account of the confusion it causes.

TABLE I
ANALYSIS OF 195 CARCINOMATA OF THE COLON
Presbyterian Hospital, 1916 to 1935 (Inclusive)

	Three Years Ago or More		Five Years Ago or More	
	END-TO-END	MIKULICZ	END-TO-END	MIKULICZ
Total Cases	61	51	47	36
Postoperative deaths	15 24 0%	14 27 4%	11 23 4%	11 30 5%
Lost to follow-up	7 11 4%	2 3 9%	11 23 4%	2 5 5%
Died of carcinoma	9 14 9%	9 17 6%	8 17 0%	10 26 1%
Died of other causes	3 4 9%	1 1 9%	3 6 3%	1 2 6%
Surviving	27 44 0%	25 49 0%	14 29 7%	12 33 3%
Survivors excluding opera- tive deaths	58%	67%	38 8%	48%
Survivors excluding oper deaths, and lost to follow- up	69%	71%	56 0%	52%
Survivors excluding oper deaths, lost to follow-up, and died of other causes	75%	73%	63 6%	54%

Late recurrences are not by any means rare. In this group, 15 recurrences were observed after the three-year period.

The attitude at Presbyterian Hospital has been eclectic. In the group of patients operated upon three years ago or more, the end-to-end anastomosis was employed in 61 cases and the multiple-stage resection in 51. No pre-conceived idea regarding anastomosis should be held when resecting a malignant tumor. Consequently an end-to-end anastomosis will occasionally be employed. At other times, a multiple-stage and occasionally a partial colectomy with permanent colostomy will be performed. The functional results after the multiple-stage resection are quite as good as after an end-to-end anastomosis.

The operative mortality is not strikingly different—24 per cent in end-to-end, and 27.9 per cent in Mikulicz or multiple-stage operations. Both figures could be improved upon.

The follow-up results likewise do not show a great deal of difference. It should be understood that a comparison is not entirely fair, because the two groups, on account of the eclectic attitude at Presbyterian Hospital, are somewhat dissimilar.

In giving results, statistics should be given that are based on all cases operated upon. Results should also be tabulated, taking into account the operative deaths, the cases dying presumably of other causes, and the cases lost to follow-up. Doctor Janssen offered the following statistics (right colon excluded). All cases had been operated upon three years ago or more (Table I).

DR ALLEN O. WHIPPLE (New York) emphasized two or three points brought out by Doctor Janssen. First, in dealing with malignancy in the bowel or in any part of the gastro-intestinal tract, one should not compromise with the node-bearing area. That is the chief objection to the so-called Mikulicz type of operation as compared to the Rankin type, or resection with an end-to-end anastomosis or the closed method of anastomosis such as Doctor MacFee mentioned. Doctor Whipple could not see how it is possible to obtain a thorough removal of the malignant growth unless the node-bearing area is removed as radically as possible. It is true that growths of the colon may not metastasize as quickly and as generally as is the case of gastric carcinoma, nevertheless, the principle holds. Another point to be emphasized is that in case of end-to-end anastomosis, whether by the open or by the closed method, the use of silk seroseous sutures rather than catgut sutures has a definite and real advantage in that both the suture material and the needles used can be much finer. There is less chance of leakage which has been borne out in the statistics of the Presbyterian Hospital. Where this form of suture has been used, there has been more than 50 per cent reduction in the occurrence of fecal fistulae. In Doctor Whipple's personal experience, some 30 per cent of cases with end-to-end anastomosis have developed more or less of a fistula. Drainage was used in those cases. Since using the seroseous suture with silk, it is become exceedingly rare to have a fecal fistula.

DR JOHN GARLOCK (New York) also emphasized the importance and value of the silk technic in surgery of the large bowel. Using fine silk minimizes to a large extent the trauma incident to the performance of an intestinal anastomosis. Doctor Garlock said he had been using fine chromic for the inner layers and silk for the outer layers. Every contemplated procedure for the treatment of carcinoma of the rectum and rectosigmoid must take into account the peripheral zone of lymphatic spread. In view of this, it is difficult to understand the rationale of the modified Mikulicz procedure for these growths. Good cancer surgery implies removal of the lymph-draining tissues as well as of the original growth. Sentimental consideration for the anal sphincter has no place in the treatment of carcinoma of the rectum. Experience in recent years has shown that a properly made colostomy causes little or no inconvenience to the patient.

Doctor Garlock took occasion to report briefly on the results of a study being conducted on his service at the Mt Sinai Hospital in collaboration with the Bacteriologic Department. This study is being carried out by Dr Gabriel Seley. A preliminary report will be published shortly. Inasmuch as all the small and large bowel cases at the hospital are grouped in this particular service, there has been an unusual opportunity of studying the various problems associated with diseases of these organs. Most of the

complications following intestinal surgery can be grouped under the main headings of peritonitis and wound infections. About one year ago, Doctor Seley began to study the bacteriology of the colon cases with the idea of developing a method of conferring immunity on the patients against post-operative infection. In addition to the experimental work in the bacteriologic laboratory, he made careful aerobic and anaerobic cultures at the time of operation. These were made from retrocolic tissues, the various layers of the bowel wall underlying the tumor growth and also from the mucosal surface of the neoplasm. In more than 90 per cent of the cases a *Streptococcus* was isolated in conjunction with *B. coli*, the enterococcus and the other intestinal organisms. The idea occurred to Doctor Garlock to administer sulfanilamide preoperatively in the hope of destroying or curtailing the activity of the *Streptococci*. In March, 1938, therefore, the purposeful preoperative administration of sulfanilamide was begun in all colon cases. Thirty cases have now been treated. Since the institution of this plan, Doctor Seley has been unable to obtain a single positive culture of *Streptococci*, although he has used the same technic as before. There has not been a single case of postoperative peritonitis and only two minor wound infections. The cultures have revealed the *B. coli*, enterococci, *B. subtilis*, etc. Theoretically, it is assumed that the *Streptococci* and the *B. coli* live in symbiosis in the large bowel. By curtailing the activity of one of these, the virulence of the other is immediately diminished. The smoothness of convalescence of these patients has been noteworthy. It should be emphasized that there has been no change in operative technic which might be considered as a possible reason for the results described. These results have been so striking as to warrant a continuation and extension of the study.

DR WILLIAM F. MACFEE (New York) said that the importance of preoperative care and postoperative support could not be emphasized too often. He noted with approbation that the obstructed cases in Doctor Patterson's series were not subjected immediately to resection. A preliminary decompression was effected in these cases and an adequate period of time was allowed for a return of the colon to an approximately normal state. He approved also of the transfusion of blood which was given in every case.

So far as the operation is concerned the preoperative complications are probably more important than the operation itself. They increase the risk no matter what kind of operation one elects to perform. Chief among these are (1) Obstruction (2) Infection, with or without abscess (3) Fixation of the tumor, or short mesentery (4) Poor general condition of the patient. It is the group of cases with complications such as these which accounts for the mortality in any series.

In regard to postoperative complications, there was, in a series of 56 cases of aseptic resections which I reported in 1937, an incidence of 16 per cent of wound infections, one of which led to a fatal evisceration. There was one internal leak with fatal peritonitis, but no occurrence of external fistulae.

The mortality for the series was nine, or 16.1 per cent. This included two patients who died of pneumonia, and one in which the aseptic resection was begun but abandoned because of a leak from one segment of colon, and the operation was concluded as an exteriorization procedure.

This is in rather striking contrast with the series of Doctor Cheever, which is quoted by Doctor Patterson. In this series there was an incidence of 27 per cent of fecal fistulae and 23 per cent had granulating wounds when discharged from the hospital. In speaking of primary resection and anastomosis, one should distinguish between the open type and the closed or aseptic type of anastomosis.

By way of countercomment, it may be noted that in the series presented by Doctors Patterson and Webb, all cases had a fistula for a period of from four to six weeks, and that 21 out of 37, or approximately 56 per cent, had persistent fistulae for a time after an attempt had been made to close the original fistula. Only ten of 51 cases, or approximately 20 per cent, of the series healed spontaneously.

It is also an interesting observation that when all of the 70 cases subjected to Mikulicz resection are taken into account the mortality statistics are 27.1 per cent. In the series which I reported from St. Luke's and New York Hospitals, with all cases included, the mortality for the Mikulicz procedure was 27.9 per cent. Whether a surgeon performs the Mikulicz or the primary resection with aseptic anastomosis, probably depends largely on which type he started with, or is accustomed to. Unless both the Mikulicz and the aseptic types of resection are being performed in the same clinic, it would seem to be difficult for one to conclude that either method is safer than the other. Exception must be taken to Doctor Patterson's conclusion that "the Mikulicz procedure is still the safest method of removing a portion of the large bowel," until he has given both methods a fair trial.

I firmly believe that if the cases reported by Doctor Patterson had been performed by the aseptic method of anastomosis and undertaken with the same care that was exercised in the performance of the Mikulicz procedure, the operative mortality record, excellent as it is, would have been even better.

DR MORRIS K. SMITH (New York) said that he had always been a devotee of the Mikulicz procedure. There are, however, certain pitfalls in its use which he had learned, sometimes through sad experience. One has been mentioned by both Doctor Patterson and Doctor MacFee, that is, the danger of stirring up peritonitis in trying to mobilize an inflamed, obstructed growth. Another difficulty is illustrated by the case of a man with a nonobstructing lesion of the descending colon. The patient was stout, and it was very difficult to mobilize the colon, so that the limbs of the spur were really too short. Things probably would have gone well if the man had not coughed so much that he eviscerated with retraction of the proximal limb of the colon, with subsequent fatality. Looking back, a cecostomy and resection with primary anastomosis would seem to have been preferable in this case.

In one apparently very favorable case, progress was quite satisfactory until closure of the fistula. Doctor Smith had closed a number without hesitating to open the peritoneal cavity in the process, and he did so in this patient. She developed an infection and ultimately died. Since then he has tried to effect extraperitoneal closures. There have been instances, however, in which the extraperitoneal closure has failed one or more times, and a subsequent attempt in which the peritoneum was opened and the intestine mobilized has been successful.

After a deep application of the Mikulicz enterotome, the opening between the two limbs often does not extend to the office of the fistula on account of the curved shanks of the clamp. Ordinarily the opening has been completed to the outside before closure of the fistula, but in a case where Doctor Smith did not do this, thinking the opening made by the blades sufficient, obstruction later developed from stricture at this point and further intervention became necessary.

DR GEORGE T. PACK (New York) asked Doctor Patterson two questions: one had to do with breaking down the figures for the patients who died with recurrence, and survived the three-year period without recurrence into those patients with carcinoma without metastasis to lymph nodes and those who had such metastasis, and the second question was whether there

was a histologic grading of the cancers in those patients who survived and in those who died

DR HOWARD PATTERSON said, in closing, that he was sorry some of those who had spoken felt that his statistics were grossly misleading. The interest of Doctor Webb and himself lay in trying to find out how efficient the Mikulicz type of procedure was in the "cure" of resectable growths of the colon. The cases deleted from the survey were those which could not possibly serve as a "test" of *any* operation. One was a young man in the twenties, who had a fulminating, diffuse peritonitis. He was thought, before operation, to have an acute perforation of a duodenal ulcer. Exploration disclosed a large growth of the sigmoid with a perforation the size of one's thumb, and much fecal matter in the abdominal cavity. He died the next day, following exteriorization of the growth, with drainage. A second case had coexisting carcinomata of both the cecum and sigmoid. Exploration showed the former to be inoperable. It was felt that the sigmoid growth might later obstruct and, therefore, a Mikulicz resection was performed. These cases are typical of those that were deleted from the study in regard to late results. It was felt that several cases that were "lost track of" after partial follow-up are probably well to-day—but they were classed as "dead of recurrence" in the survey. The cases were not divided into those with and without extension to regional lymph nodes for the reason that the total number of cases was too small to make such a study valuable.

ADAPTATION OF THE MIKULICZ OPERATION FOR THE RIGHT COLON AND RECTOSIGMOID *

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The Right Colon—The operation of Friedrich, removal of the lower six inches of the ileum, the cecum, the ascending colon, and about one-third of the transverse colon has been quite generally adopted for growths in the cecum and ascending colon. The growth and the lymphatic area attached are removed when the ileocolic, right colic and the lateral branches of the middle colic arteries are divided as near as possible to their origin from the superior mesenteric and middle colic vessels. The best methods of joining the ileum to the colon and of repair of the raw surface on the posterior abdominal wall are still under debate in the surgical literature.

The Mikulicz¹ method of intestinal anastomosis is apparently gaining favor among surgeons for use following the Friedrich resection. The method that has been employed with satisfactory results in performing the Friedrich resection and Mikulicz anastomosis is shown in Figures 1 to 10.

The general advantages of the Mikulicz method of anastomosis apply themselves in this instance. The method of repair of the raw surface on the posterior abdominal wall is adequate for the removal of the entire lymphatic area attached to growths in the cecum and ascending colon. Prior to the use of this means for repairing this defect the area could not be covered when an adequate lymphatic drainage field was removed.

The Rectosigmoid—The removal of growths from the low sigmoid and upper rectal zones has passed through an interesting phase. After Lisfranc's³ perineal excision of the rectum in 1820, there seems to have been little technical progress made until 1874, when Kocher⁴ and Verneuil⁴ independently widened the scope of this operation by removing the coccyx. From this time until 1900 the development of an adequate operative approach has proceeded rapidly. In 1883, while assisting Volckmann in the removal of a sarcoma of the sacrum, Kraske saw a large portion of the sacrum removed and the sacral canal opened without untoward results. From this he rightly concluded that the lower sacrum could be resected in the operative approach to rectal carcinoma. This step provided exposure sufficient to remove a larger segment of rectum, and provided adequate exposure for reanastomosing the bowel without sacrifice of the sphincters. Primary anastomosis was first attempted, but unsatisfactory results led him to discard this for suture of the anterior half of the bowel followed by secondary closure in the sacral wound after it had begun to granulate. The first successful abdomino-perineal re-

* Read before the New York Surgical Society, January 11, 1939. Submitted for publication December 19, 1938.

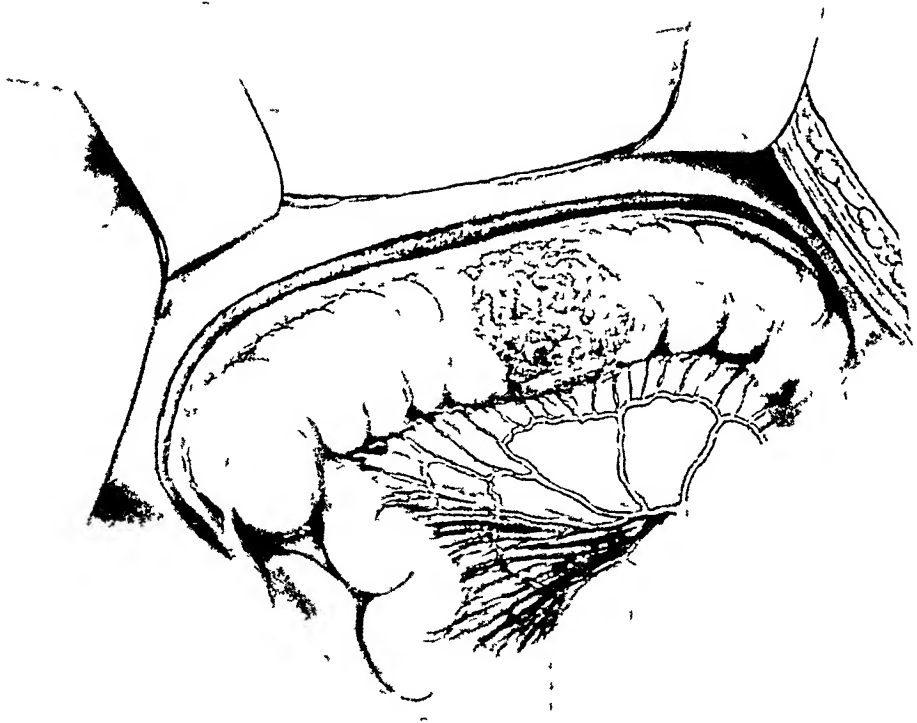


Fig 1—Incision through the lateral border of the rectus muscle sufficiently long to afford ample exposure of the entire right abdominal cavity. Open abdomen. A view of the growth, and the incision along the right lateral gutter which divides the lateral peritoneal attachment of the cecum and ascending colon.



Fig 2—The dissection inward of the cecum and ascending colon, thereby forming a false mesentery.

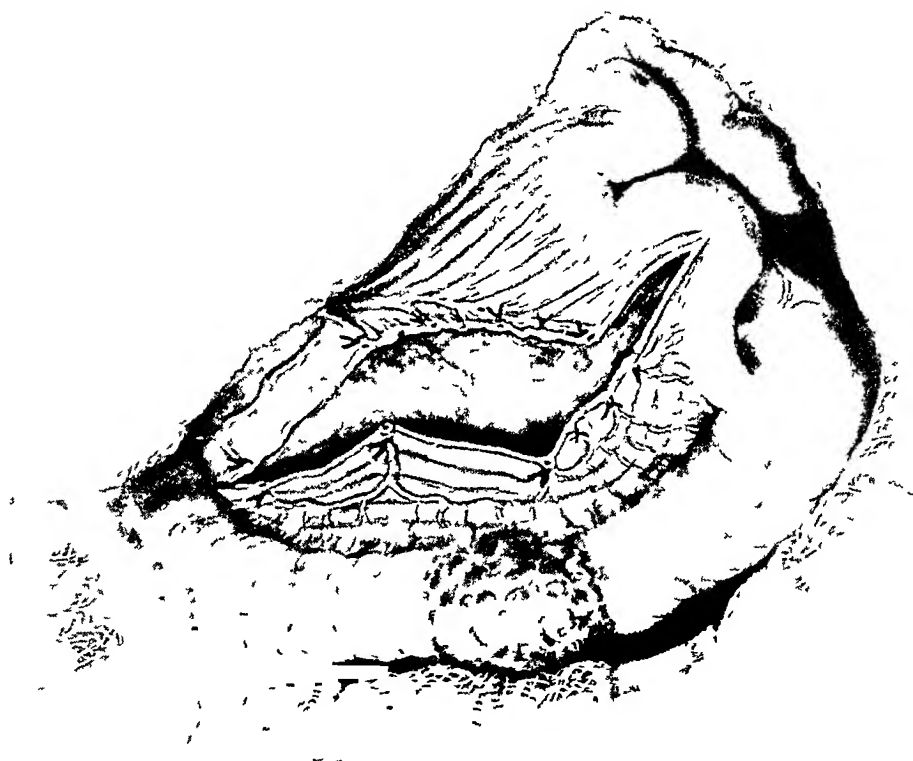


FIG 3—Division of the ileocolic, the right colic and the lateral branches of the middle colic arteries close to their origin and splitting of the mesentery of the lower ileum and the false mesentery of the cecum and colon

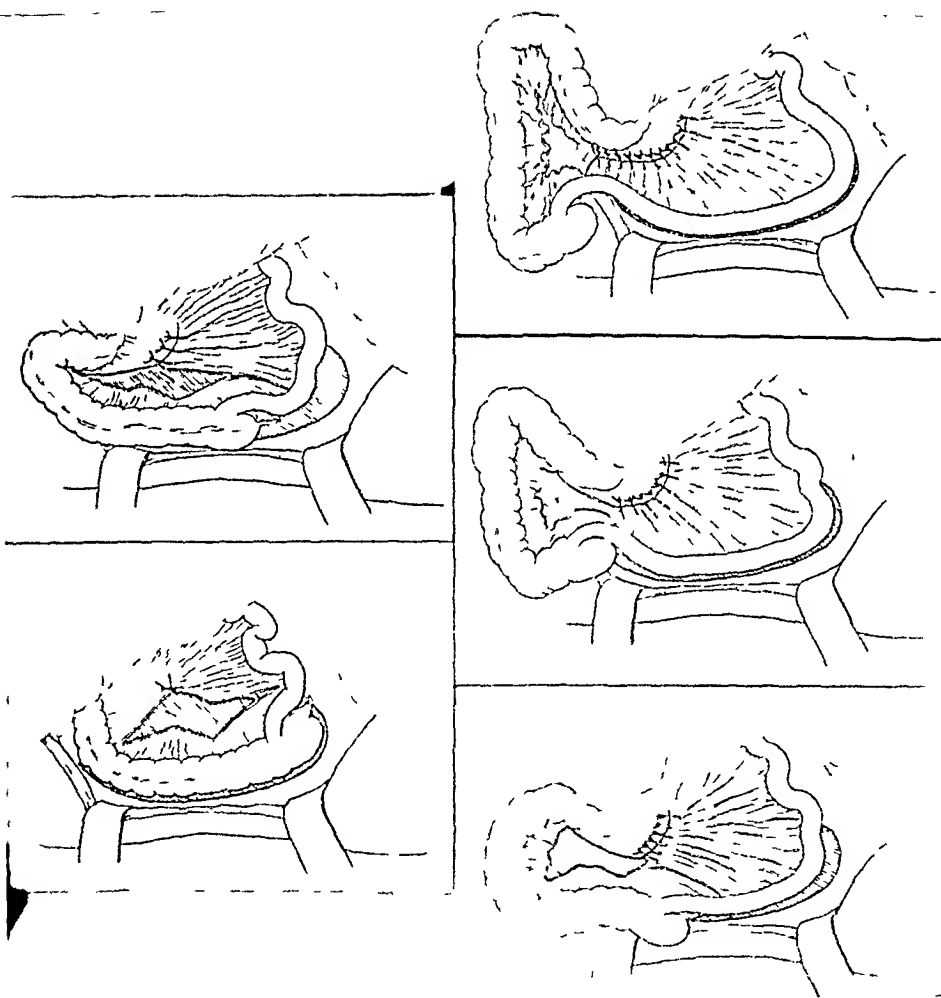


FIG 4—Diagrammatic representation showing the method of suture of the divided mesentery of the ileum to that of the cecum and ascending colon. As these sutures are placed the cecum and ascending colon are raised up and through the upper angle of the abdominal incision. The last suture approximates the serous surface of the lower ileum to the transverse colon

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section was performed by Boeckel,³ in 1896, in a patient in whom he found himself unable to deliver a growth by the Kiaske operation. During this same year, the first case in which the areas of lymphatic drainage were



FIG 5—The mesenteric attachment completed. The white band of the colon is shown sutured to the adjacent serous surface of the ileum through which the stomal clamp will later cut a new opening. The lateral serous surface of the ileum, which naturally approximates the lateral cut surface of the posterior peritoneum, is sutured to its free border. Additional sutures are taken in the posterior surface of the mesentery of the ileum to attach it to the posterior abdominal wall from the angle of the mesenteric suture down to the lower point of attachment of the incision in the posterior parietal peritoneum. The open posterior abdominal wall is thereby completely covered by the ileum and its mesentery.

removed was performed by Giordano.³ The final contribution to the radical approach was made by Miles⁵ in 1908, when he reported his classic abdomino-perineal operation which removed the primary growth and all the areas of

local metastasis, namely, the ischioectal fossae, nodes along the levator ani, adjacent bowel, and the mesosigmoid and aortic nodes. The pathologic basis for the radical operation was not described in full until 1910, when Handley⁷ clearly showed the metastases present in the submucosal lymphatics 5 to 12 cm proximally in the intestinal wall.

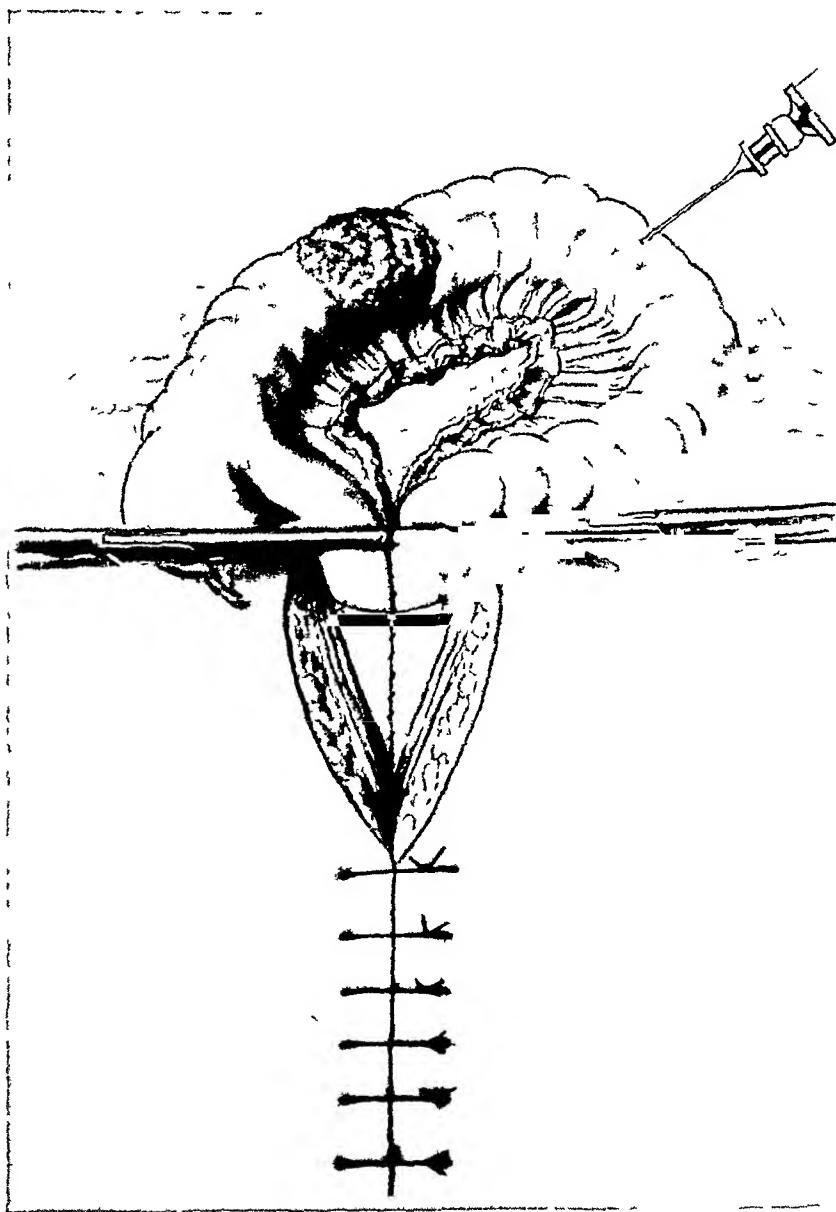


FIG 6—Closure of the abdominal wall in layers. Clamping of the colon and ileum. Injection of the loop with formalin solution to prevent deterioration of the specimen during the time it is left in place on the abdomen.

While the radical procedure with the permanent colostomy was being developed there was an effort made to remove the growth and preserve the sphincters. During the developmental period these operations fell into two general types. The first comprised those operations in which the growth and all bowel distal to it were removed and the proximal end brought through

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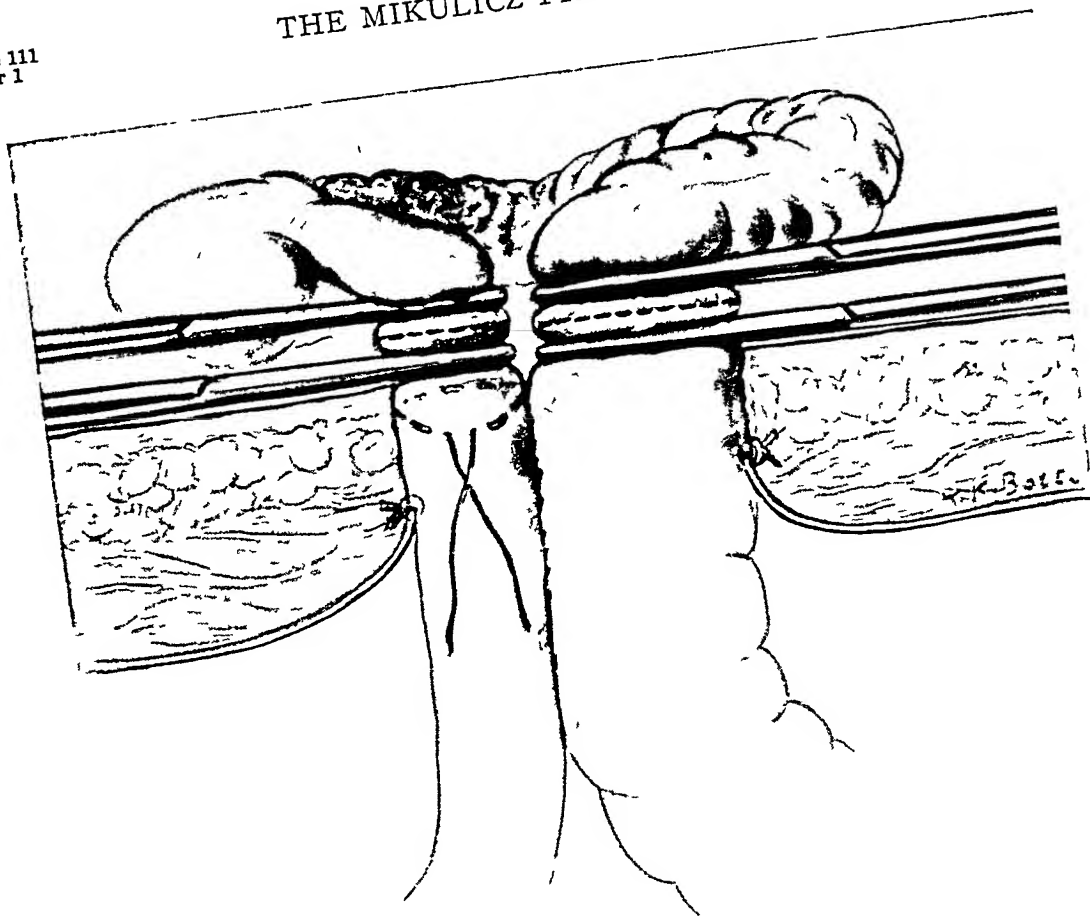


FIG 7—Method of attachment of the peritoneum as close up to the crushing clamps as possible, to enhance retraction of the mucous membrane edges away from the skin edges when the clamps have been removed. Purse string suture placed around the ileum and left untied.

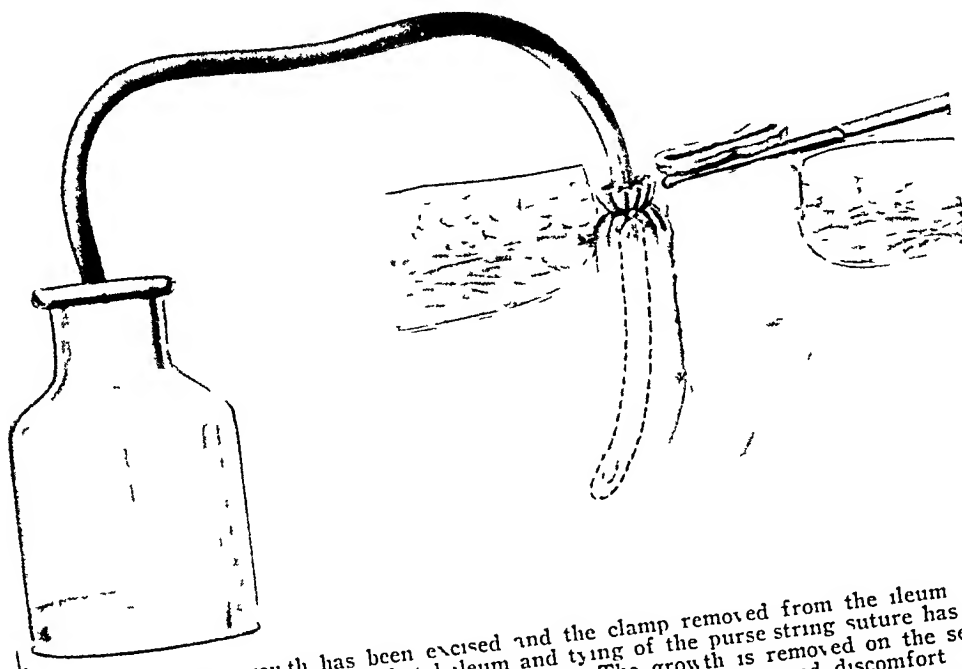


FIG 8—The growth has been excised and the clamp removed from the ileum. In section of a rectal tube into the distal ileum and tying of the purse string suture has been done to prevent leakage of feces into the wound. The growth is removed on the second or fourth day, depending upon the degree of abdominal distention and discomfort. The ileum has retracted away from the skin margins. The clamp on the colon prevents intra-abdominal retraction. The suturing of the ileum to the colon prevents the retraction of the ileum into the abdominal cavity.

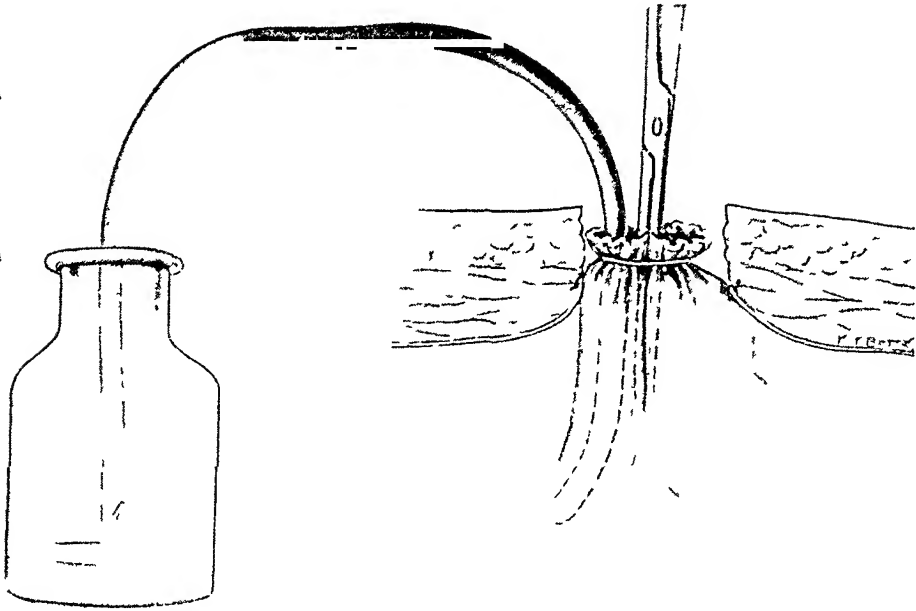


FIG 9—Shows a ligature passed around the proximal colon and distal ileum colon crushing clamp removed stoma clamp in place, and surrounding ligature tied tightly about the open ends of the colon stoma clamp and ileum. The stoma clamp should be supported by the dressing to prevent its full weight from resting on the intestine. The protruding ends of the colon and ileum are strangulated by the ligature, which results in the open margins resting about the level of the peritoneum as soon as the stoma clamp comes free. This greatly facilitates healing of the stoma without secondary operative closure.

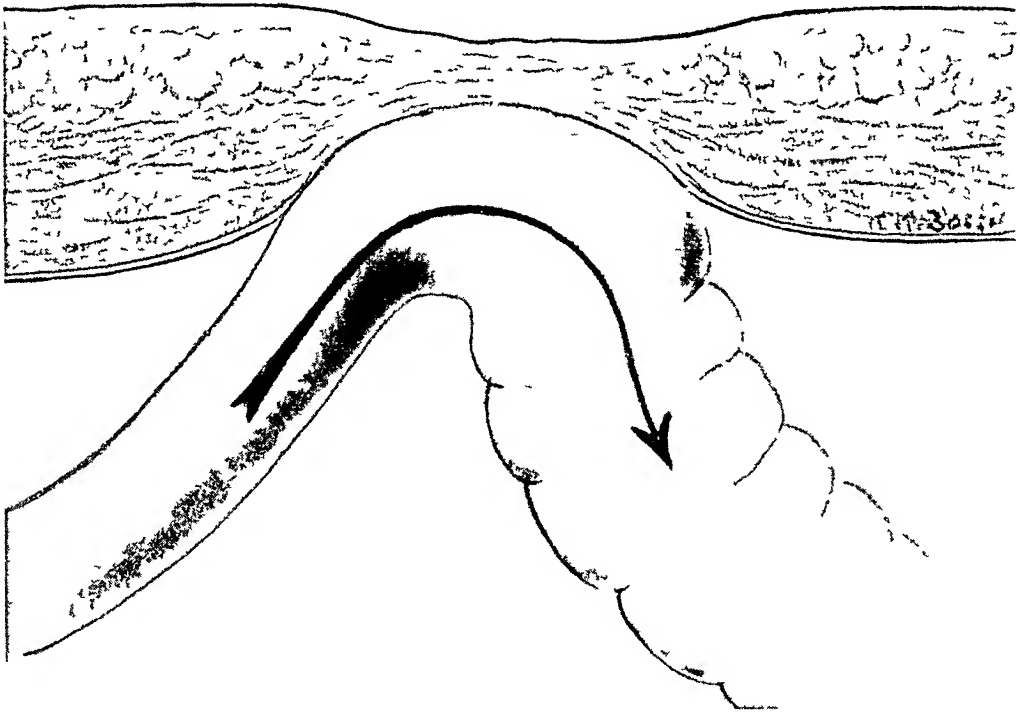


FIG 10—Shows the result following spontaneous closure. The last three patients have closed spontaneously in from eight to 12 weeks. The drainage on the abdominal wall of liquid feces is readily controlled in patients in whom there is primary union of the rest of the abdominal wound, the spur is cut deeply, and adhesive tape is strapped tightly across the edges of the wound over the open ends of the intestine.

the sphincters and sutured to the skin. The second group consisted of procedures in which the sphincters were conserved and the continuity of the intestine reestablished by end-to-end suture or by intussusception of the proximal intestine into the distal segment. The major objections were the liability of stricture formation, the peritonitis hazard, and the incomplete removal of the adjacent lymphatic drainage areas.

The first application of the Mikulicz principle for reestablishment of the continuity of the rectum with conservation of the sphincters was performed by Kuttnei.⁸ In 1910, he reported 10 cases in which the growth had been removed and a double-barreled colostomy made in the Kraske incision. The spurs had subsequently been divided and the colostomies closed with satisfactory functional results. There was one death in the first series. Little is to be found on this phase of the subject until 1924, when Kuttnei⁹ reported several hundred cases operated upon by this method. In this series there were 36 per cent three-year cures, and 24 per cent five-year cures. Of these patients 52 per cent had perfect continence while 17.6 per cent had almost complete control.

Figures 11 to 14 illustrate the operation herein described, which has been performed upon selected cases since June, 1934. It is a combination of the Miles⁶ procedure and Kuttnei's sacral anastomosis by the Mikulicz method. The remaining fistulae have been treated variously (Table I).

TABLE I

Case	Sex	Age	Operation	Duration of Symptoms	Location of Growth			Complications	Secondary Opening Edges	Present Condition	
					High Rectal	Recto sigmoid	Low Sigmoid			Normal Movements	Stricture
L. J.	I	62	6-15-34	3 mos			+	None	One	+	Mod No dilatation
J. S.	M	52	7-14-36	2 mos		+		None	One	+	Mod Dilatation
L. C.	M	58	1-27-37	8 mos		+		None	One	+	None
M. S.	F	60	2-28-38	6 mos	+			None	One	+	None
M. B.	M	48	3-11-38	4 mos			+	None	One	+	+ Fistula
J. M.	M	63	2-28-38	7 mos	+			Perforation	Died	Died	Died of peritonitis
G. H.	F	43	3-26-38	1 mo		+		None	None	+	Mod Dilatation
A. F.	M	48	8-17-38	6 mos			+	None	None	+	None Small fistula

Voluntary closure of the fistulous opening, without operative assistance seems to be more probable in a higher percentage of cases as our experiences increase. The average length of time for closure has been three to five months. The bowels begin to move partially, on an average, at about the eighth week.

The disadvantages of this operation are legion. The patience of the surgeon as well as that of the patient is tried severely by the discharge of the fistula in the sacral position. The most important factor in promoting voluntary closure of the rectal fistula lies in keeping the margins of the mucous

membrane of the intestine far enough away from the skin edges to prevent union of the two edges. To control this factor the crushing clamps should be applied flush with the skin and with as much traction on the two loops

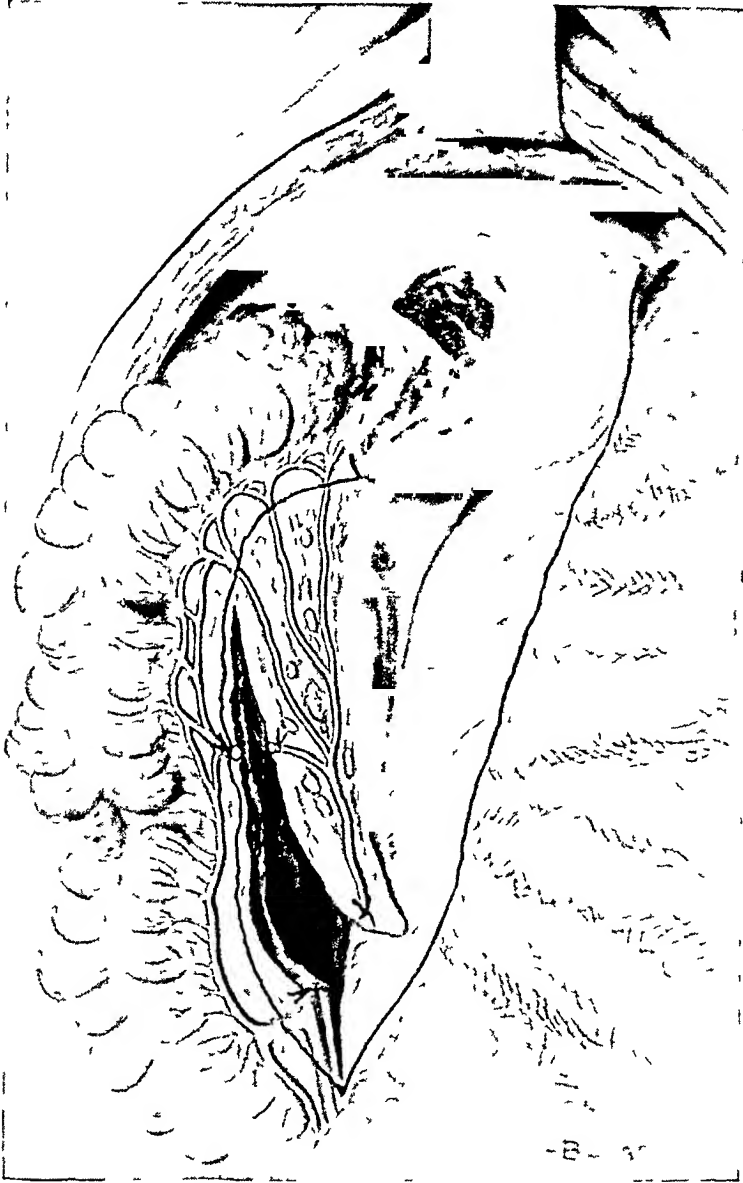


FIG 11—The first portion of the operation consists of a celiotomy at which time the mesosigmoid is mobilized. The node bearing area at the bifurcation of the aorta and the mesosigmoid is mobilized for removal during the delineation of the peritoneal leaves. The trunk of the inferior mesenteric artery is then ligated just below the left colic artery, care being taken to leave the marginal sigmoid branches intact. The rectum is mobilized from above by dissection into the hollow of the sacrum and behind the bladder. This dissection is carried down to the levator muscles taking with the rectum all fat and nodes contained in this region. A tape is tied to the rectum to facilitate delivery through the sacral wound. The abdomen is then closed by temporary interrupted sutures and the patient placed in the Sims position.

as the circulation will withstand. During the immediate postoperative period the edges of mucous membrane can be depressed away from the skin margins by packing the cavity with gauze. Operative freeing is necessary when the

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mucous membrane edges and skin margins unite. Prolapse of the sigmoid through the fistula has occurred in one patient with interference in healing of the fistula. In this instance the distal sigmoid was shortened under anesthesia.

Attempts to close the fistula after the first three or four weeks have all resulted in a breakdown of the suture line after a few days from the pressure of a collection of feces in the rectum. When this procedure is attempted the rectal sphincter must be divided (ref. Case L. C., Table I).

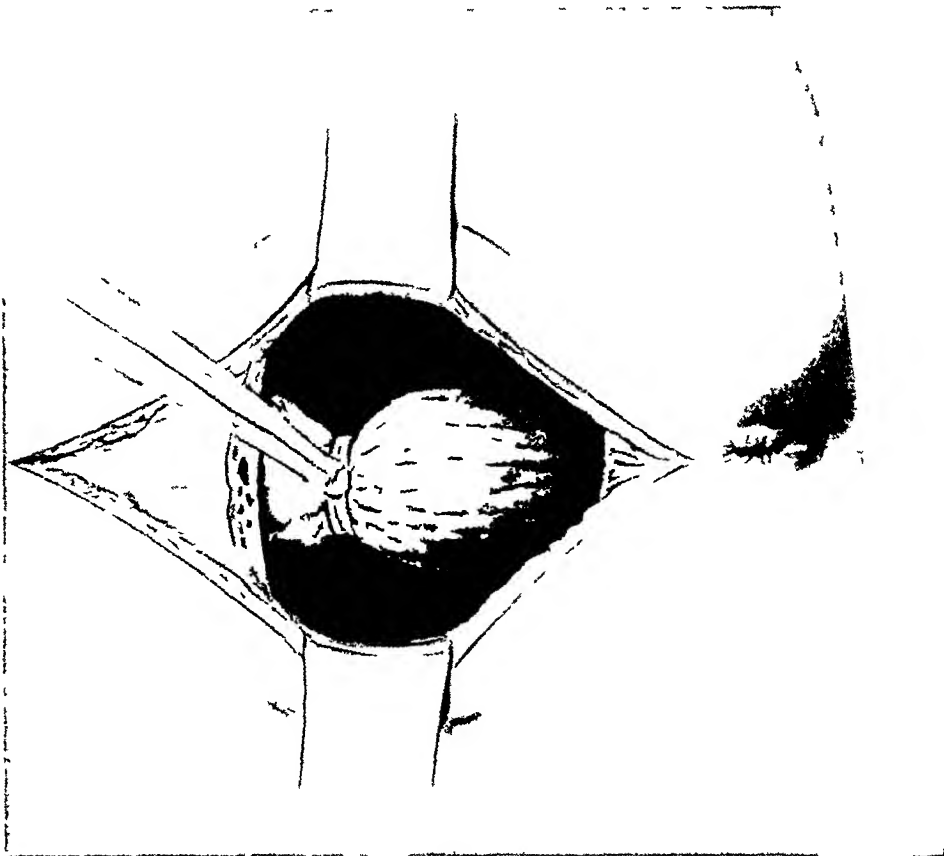


FIG. 12—A longitudinal incision is made over the sacrum and coccyx and the latter disarticulated and removed. This step opens the pelvic cavity from below and the growth is delivered through this aperture.

The outcome in the first patient in 1934 was unusually fortunate in that the patient withstood the operation well, healed completely and has not been disturbed by the moderate stricture remaining. Had the postoperative course in this patient been as trying as in the third patient in Table I, the procedure might have been discontinued as being impractical.

The stricture of the union area that results from the procedure will necessitate dilatation during the first six months of the postoperative period. Finger dilatation without anesthesia has sufficed in all instances except Case J. S. In that patient there was a slough of the proximal sigmoid which resulted in an area of one inch of the rectal zone made up of an epithelized area of scar tissue. Following manual dilatation under anesthesia this patient has normal bowel function with finger dilatation about once a month.

There have been no recurrences in any of the patients operated upon to

date Further observation of a larger series will be necessary to evaluate this method against the completed Miles operation

The unquestioned advantage of this method lies in the lack of contamination of the abdominal cavity and of the pelvic cavity during the primary operation In this one fact lies the chief justification for the time consumed and the patience necessary to carry out the procedure

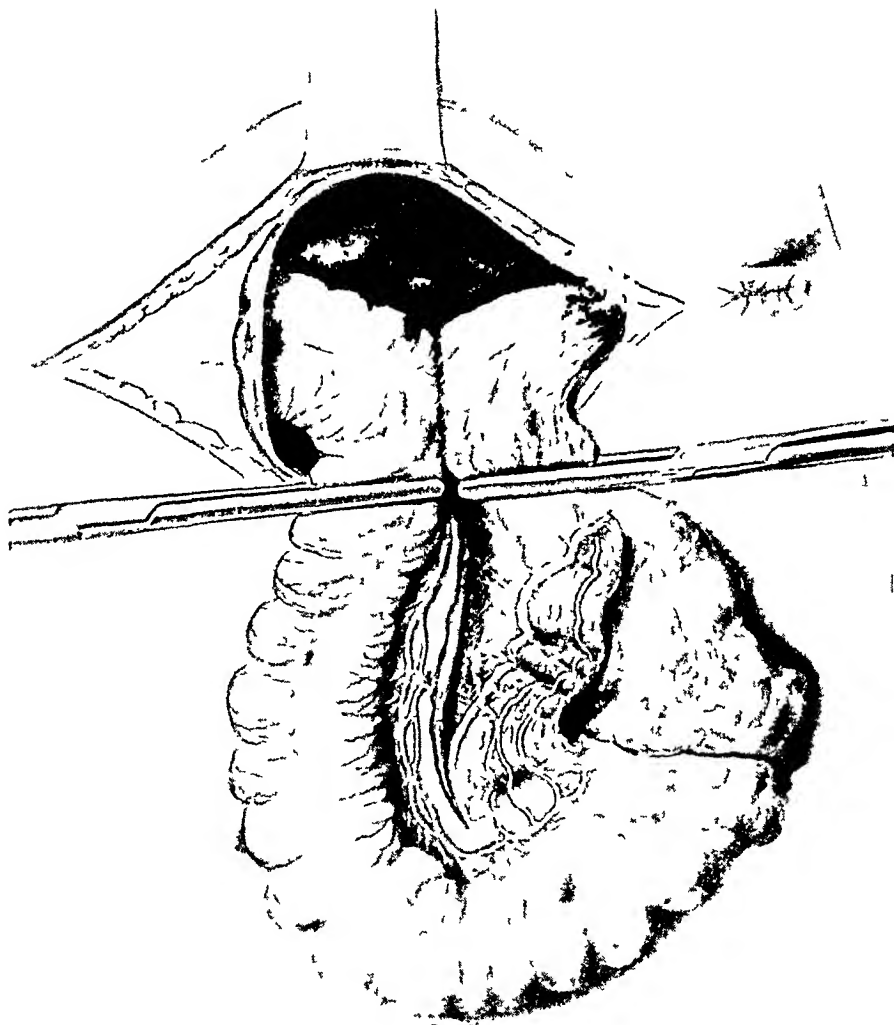


FIG 13—When as much healthy intestine has been delivered on each side of the growth as is possible the adjacent limbs of sigmoid and rectum are united The Mikulicz clamps are applied without undue tension on the circulation of the loops, including the marginal artery of the sigmoid The wound is loosely closed about the exteriorized loop The patient is then placed on his back and the abdomen reopened The peritoneal incisions are closed about the sigmoid as it descends into the pelvis, thereby making an intact pelvic floor for the loops of the small intestine to lie upon

Three to four days later, when the sacral wound has become sealed off the growth may be removed and the marginal sigmoid artery clamped The proximal opening is allowed to function as a temporary colostomy

In this one advantage over other methods, the authors are satisfied when they compare their experience in this method with any other in which the sphincter action of the anus is retained Preserving the sphincter is a matter about which there has been a great difference of opinion expressed for opera-

tions upon growths of the rectosigmoid. The patients in our small series were not promised a preservation of the sphincter before operation. This is a matter that should be finally decided at the operating table. The primary area of metastasis of growths in the upper rectum and low sigmoid is removed by the operative procedure herein described. Those instances, in which metastases have been found outside the usual primary zone, are mainly those in which the superior, secondary zones have been invaded. This operation

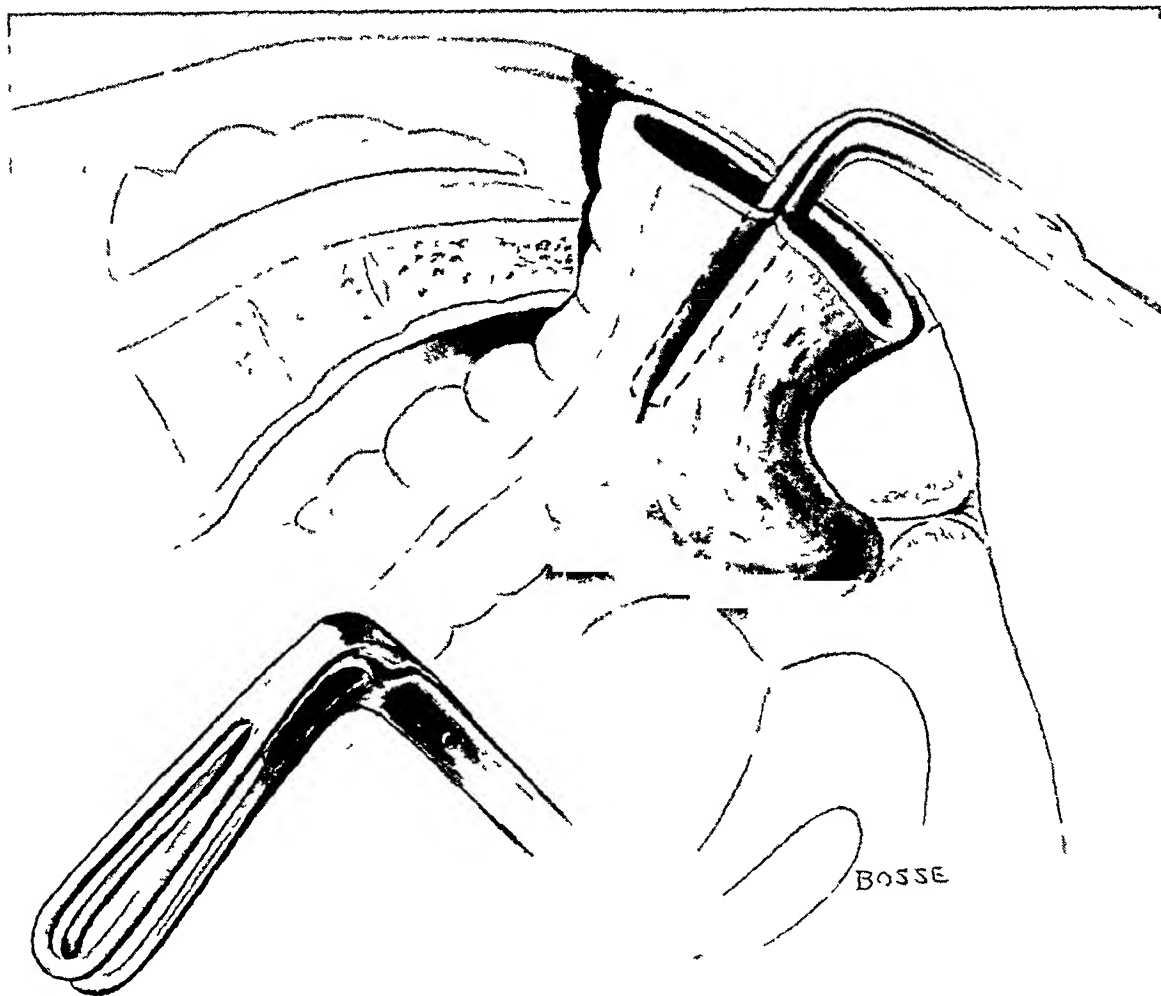


FIG. 14.—The spur formed by the resulting double barreled colostomy should be cut away after the fifth to seventh day by the application of a crushing clamp. The olive shaped clamp takes a larger bite which reduces the tendency for postoperative stricture.

may sacrifice the removal of a possible inferior, secondary zone that is rarely invaded by metastases. The superior, primary lymphatic zone is removed as radically as it is possible with any operative procedure.

REFERENCES

- ¹ von Mikulicz, J. Chirurgische Erfahrungen über das Darmcarcinom. Arch. f. Klin. Chir., 69, 28-47, 1903.
- ² Moynihan, Lord Berkeley. Abdominal Operations. Third Edition. Philadelphia, W. B. Saunders Co., 2, 25, 1915.
- ³ Goullioud, P., and Faysse, G. De l'Amputation Abdomino-Périnéale du Rectum Cancéreux. Revue de Chirurgie, 31, 711-735, 1905.

- ⁴ Mayo, C H Evolution in the Treatment of Cancer of the Rectum J A M A , 40, 1127-1129, April 25, 1903
- ⁵ Miles, W Ernest A Method of Performing Abdomino-perineal Excision for Carcinoma of the Rectum and of the Terminal Portion of the Pelvic Colon Lancet, 2, 1812-1814, December 19, 1908
- ⁶ Miles, W Ernest The Radical Abdomino-perineal Operation for Cancer of the Rectum and of the Pelvic Colon Brit Med Jour , 2, 941-944, October 1, 1910
- ⁷ Handley, W Sampson Hunterian Lectures on the Surgery of the Lymphatic System Brit Med Jour , 1, 922-929, April 16, 1910
- ⁸ Kuttner, H Zur Operation hochsitzender Rektumkarzinome Zentralbl f Chir , 37, 604, April 23, 1910
- ⁹ Kuttner, H Soll man bei der Operation des Rektumkarzinoms in jeden Falle den Sphinkter opfern? Zentralbl f Chir , 51, 1119-1120, May 24, 1924
- ¹⁰ Lahey, F H Resection of Right Colon and Anastomosis of Ileum to Transverse Colon after Mikulicz Plan New England J Med , 206, 315-322, February 18, 1932
- Idem* Surg , Gynec & Obst , 54, 923-929, June, 1932
- ¹¹ Woodhall, B Modified Double Enterostomy (Mikulicz) in Radical Surgical Treatment of Intussusception in Children Arch Surg , 36, 989-997, June, 1938

DIAGNOSTIC PARACENTESIS IN SUSPECTED INTRA-ABDOMINAL HEMORRHAGE

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TRAUMATIC RUPTURE of abdominal viscera may be among the most difficult and treacherous of diagnostic problems which confront the surgeon. To simplify this perplexing situation, the use of abdominal paracentesis has been suggested as a quick, simple, safe and satisfactory means of determining the presence of intra-abdominal hemorrhage. What with the steady progress of high speed mechanization and the ever increasing tempo of civilization, the incidence of this catastrophe is definitely on the increase.

Commonest among visceral injuries produced by nonpenetrating abdominal trauma is rupture of the liver or the spleen, or both. Gill, in discussing the incidence of subcutaneous rupture of abdominal viscera, states that rupture of the liver comprises 59.9 per cent of these injuries, while injury to the spleen accounts for 33 per cent. In other words, 92.9 per cent of such injuries are associated with intra-abdominal hemorrhage which, if not expeditiously cared for, will result in tragedy. Boljaïsku¹ reports a mortality of 83.3 per cent following rupture of the liver. In a series of cases operated upon, those subjected to surgery within the first two or three hours suffered a mortality of 15 per cent, while delay of 24 hours or more caused a rise in the mortality rate to 50 per cent. Thole⁵ records a mortality of 36 per cent for the first six hours, and 86.3 per cent in those seen after 24 hours.

The mortality following rupture of the spleen, in a series of 12 cases reported by B. M. Vance,⁶ was found to be 25 per cent, although it is usually quoted as being higher. That the occasional case will survive in spite of neglect has been repeatedly shown. The well-known tendency of delayed hemorrhage in splenic rupture makes the latter even more treacherous in its subtle potentialities. From such evidence one must conclude that early enterprise is the prelude to success, while procrastination is fraught with danger, for these patients, once past the stage when surgical intervention is possible, follow a rapidly failing course and are soon beyond help of the most energetic supportive measures.

Rupture of the liver or spleen is too often associated with other serious injuries which serve to confuse the issue. Multiple fractures, head injuries, lower chest trauma, shock from exposure, and countless other factors may obscure the diagnosis in such a way as to far overshadow the insidious progress of intra-abdominal hemorrhage. The misfortune of operating upon such cases too late, or not at all, is probably of more common occurrence than would ordinarily be suspected, and for this reason one seems justified in reporting two instances in which abdominal paracentesis was employed to

substantiate vague but suggestive evidence of intra-abdominal hemorrhage. In each case the abdominal cavity was found on exploration to contain over 1,000 cc of blood, with free bleeding of alarming magnitude. Delay, sufficient to have warranted surgical intervention upon clinical findings only, would certainly have proved fatal in one instance, and probably in both.

A brief survey of the literature reveals that abdominal puncture for diagnostic purposes was first described by Solomon, in 1906. Sahli advocated its use in diagnosis of appendiceal abscess and, in 1912, Panichi reported its employment. In 1921, Savaniand⁴ described two cases of ruptured liver diagnosed by abdominal puncture. Both recovered following operation. In a third case, which proved to have a ruptured spleen, puncture was undertaken after several hours' observation. The diagnosis of hemoperitoneum was made, but surgery was of no avail. Delotti, in 1922, reported eight cases of hemoperitoneum, confirmed at operation, in which six of 11 exploratory punctures were negative. He attributes this failure to the use of a short, fine needle only slightly larger than the average hypodermic needle. Denzer devised a trocar with a capillary tube for the study of peritoneal fluid in infants. In 1925, Neuhoof and Cohen³ published an interesting article on a large series of cases in which abdominal puncture was employed in the diagnosis of acute intraperitoneal disease. Several traumatic cases were included. Vance reported its value in a patient with a ruptured spleen. For the procedure, various writers have used needles ranging in size from a large hypodermic needle to that of a lumbar puncture needle. A small trocar was used by some.

Technic of Procedure—In the two cases herewith reported, a trocar, 0.5 cm in diameter, was introduced at a point just lateral to the rectus muscle and 2.5 cm above the umbilicus. Novocain was injected down to the peritoneum. A small skin incision was made and the trocar introduced on either the right or left side, depending upon the location of the injury. On withdrawal of the plunger point, blood welled up in each instance. The plunger point was reintroduced, the trocar withdrawn, a sterile dressing applied, and the patient sent to the operating room immediately.

CASE REPORTS

Case 1—At 3:00 P. M., July 22, 1937, M. S., colored, female, age 17, walked into the University of Maryland Hospital, suffering from a stab wound of the left chest, said to have been inflicted with a penknife at 1:00 A. M. the preceding morning (14 hours previously). The wound, 1 cm long, passed through the eighth interspace in the left posterior axillary line.

Examination revealed no evidence of fluid or air in the chest. The abdomen was negative and pulse normal. The wound was dressed and the patient admitted for observation. About two hours after admission the patient felt weak, sat up and fainted. Pulse 100, blood pressure 100/48. The abdomen was somewhat distended and doughy to palpation, but exhibited no tenderness or muscle resistance. There was questionable dullness in the flanks. Paracentesis through the left abdominal wall revealed blood and the patient was sent to the operating room immediately. As her condition was becoming rapidly worse, intravenous fluids were administered.

Operation—Under gas-oxygen-ether anesthesia, the abdomen was opened through an upper abdominal transverse incision. The peritoneal cavity was found to be full of

blood 700 cc of which was collected in citrate, as soon as the splenic pedicle could be compressed between the fingers, and autotransfusion was begun. A small wound, 1 cm in length, was found at the upper pole of the spleen. Bleeding was controlled with one mattress suture of well softened No 2 catgut. The abdomen was closed, and the patient returned to the ward in good condition. Eight days postoperatively, she developed an intestinal obstruction, and was reoperated upon through a left rectus incision. The obstruction was released and recovery thereafter was uneventful, the patient being discharged on the twenty-seventh day.

Case 2—On July 22, 1937, W. M., colored, male, age 28, was admitted to the University of Maryland Hospital, immediately after having been kicked in the right chest. The patient was intoxicated, but was apparently suffering considerably.

Examination revealed marked limitation of expansion of the entire right chest with dullness extending from the point of the right scapula downward. The entire lower right chest was extremely painful even to gentle pressure, and the right upper rectus and flank muscles were rigid, in contrast to the fair relaxation of the abdominal muscles on the left side. Blood pressure 90/50, pulse 100. Having just demonstrated the efficacy of diagnostic paracentesis in the first case not two hours previously, the procedure was repeated without delay. The trocar was introduced on the right side this time and blood welled up on withdrawal of the stilet. The patient was sent to the operating room, and operated upon within one-half hour of his injury.

Operation—The abdomen was opened through an upper transverse incision, and the peritoneal cavity was found to be filled with blood. A rent in the right lobe of the liver, four and one-half inches long, extending from the dome posteriorly well through the lower edge, was revealed, the bleeding was profuse. The tear was closed with four mass sutures of well softened, double No 3 catgut. As bleeding appeared to be completely controlled, the abdomen was flushed with hot normal saline solution, and closed without drainage. The patient was returned to the ward in fair condition, but on the second postoperative day, developed signs of pneumonia in the right base. He recovered from this and was discharged on the seventeenth day following operation.

CONCLUSIONS

- (1) Abdominal puncture as described above is easily, quickly, and simply performed.
- (2) Danger of visceral injury is negligible.
- (3) It substantiates at once, and without question, the uncertain diagnosis of hemoperitoneum, which may otherwise be very difficult to make.
- (4) The loss of valuable time, due to uncertainty, is obviated.
- (5) If blood is not found, no harm has been done, but it must be remembered that delayed bleeding is commonly seen in rupture of the spleen.

REFERENCES

- ¹ Boljarsku Beitr klin Chir, 89, 587, 1914
- ² Delotti Bull Soc d Chir d Paris, 48, 1174, 1922
- ³ Neuhof, H., and Cohen, I. ANNALS OF SURGERY, 83, 454, 1926
- ⁴ Savariaud Bull Soc d Chir d Paris, 47, 878, 1921
- ⁵ Thole F. Neue Deutsch Chir, 5, 4, 1912
- ⁶ Vance, B. M. Arch Surg, 16, 631, 1928

RECTAL MALFORMATION

CASE REPORT

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In this preliminary report, a single case of congenital absence of the anus and lower rectum is being presented. It illustrates the value of preoperative diagnosis by roentgenologic study in determining whether the operative approach should be perineal or abdominal. Furthermore, the author would like to present a new method of lining the fibromuscular space between the anus and rectum in cases where the rectal pouch cannot be brought down and sutured to perianal skin.

Case Report—Infant M. D., female, born at 10 45 A.M., April 12, 1938, following a normal delivery. A diagnosis of imperforate anus was made when no meconium was passed at the time of delivery.

Physical Examination—Eighteen hours after birth. The patient was a rather puny infant, with rapid and shallow respirations. The abdomen was uniformly distended, there were no masses palpable. Upon straining, there was some bulging of the entire perineum and no particular area seemed to "point" (This is in contrast to the lack of bulging noted during the first eight to 12 hours after delivery.) A very superficial puckering of the skin was noted where the anus would normally have been located. This was bisected by the median perineal raphe, which extended from the posterior fourchette toward the coccyx. Stimulation of the area with forceps elicited slight, but questionable, contraction of the underlying sphincter.

The external genitalia appeared normal, but search for a urinary meatus failed to reveal any. The child had not voided up to the time of operation—probably incidental to beginning dehydration. The child voided ten hours after operation and continued to do so until death, although the meatus was not identified until postmortem examination was made.

Roentgenologic studies were carried out as have been suggested by Wangenstein and Rice.³ The child was held up by the feet in front of a vertical screen and a plain roentgenogram of the abdomen obtained. It has been noted by Ladd and Gross,² and Berman,¹ that errors in diagnosis may easily occur during the first 24 hours of life. We have confirmed this by taking roentgenograms at eight, 18, and 24 hour intervals after birth, and the findings have, almost invariably, shown that the longer one can reasonably wait before operating, the more accurate will be his preoperative roentgenologic examination. Berman¹ has suggested that the fluoroscope be used and that massage of the abdomen, especially over the sigmoid area, be made so as to facilitate the migration of gas into the rectal pouch. The rationale of taking this preoperative roentgenogram is that intestinal gas will seek the highest point in the obstructed intestine. With the child in the inverted position, this should be the blind rectal pouch.

In this case the roentgenogram taken at eight hours showed no gas visualized. However, by waiting until the period between 18 to 20 hours, we were able to demonstrate in this, and in the majority of other cases seen to date, the level of the rectal pouch.

The usual preoperative subcutaneous injections of saline and glucose were administered and the infant was operated upon, 21 hours after birth.

Submitted for publication October 19, 1938

Operation—With the child in the lithotomy position, two incisions were made across the anal area (Fig 2) The apex of each skin flap was elevated and a skin flap obtained by subcutaneous dissection The skin flaps were freed backward for approximately 2 cm Blunt dissection was next carried out to create a tunnel from the perianal skin to the rectal pouch This was effected within the sphincter, and most of the deeper dissection extended posteriorly along the hollow of the sacrum into the space normally occupied by the rectum This direction was followed to avoid injury to the genito-urinary tract The rectal pouch was identified at a level of $3\frac{1}{2}$ to 4 cm from the skin It was freed around its edges, especially posteriorly and laterally, until one could feel the promontory of the sacrum with the index finger After this procedure, traction failed to bring the

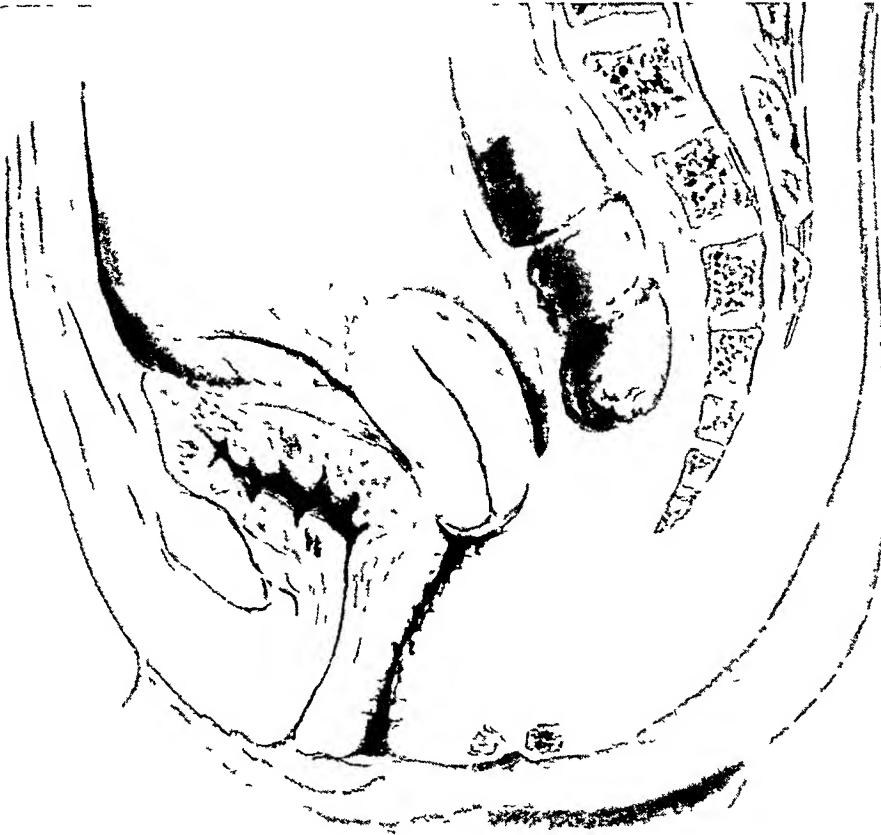


FIG 1—Midline section showing level of rectal pouch and position of sphincter muscles

pouch down to the level of the perianal skin We had anticipated this with such a high-lying blind rectal pouch, and the skin incisions had been made accordingly

The apex of the rectal pouch was next opened and the meconium allowed to escape The operative field was flushed out with peroxide and saline, and the apex of each skin flap sewn to its adjacent rectal wall (Fig 5) Silk sutures were used, which included the entire thickness of the bowel wall They were left long and hung out through the newly created anorectal canal Upon release of traction, the rectal pouch ascended and drew the skin flaps upward with it (Fig 5)

The intestinal tract thus created had, therefore, an opening through the sphincter, and there was some degree of continuity between the edges of the skin and mucosa A No 18F catheter was left in place at the conclusion of the operation

Subsequent Course—The postoperative course was uneventful, and by the twenty-fifth day the canal would admit a No 28F catheter The scar tissue was firm, however, as it is usually three to four months before such canals become soft and pliable Unfor-

tunately the child developed an intractable diarrhea during the last five days of life and expired 33 days after birth

Autopsy—There were no general findings other than dehydration and signs of rapid cachexia. There were no associated congenital anomalies. Examination of the colon revealed it to be of normal caliber throughout. There were no areas of stenosis, bands, adhesions, or dilations. The rectal pouch ended just below the level of the reflection of the peritoneum and the anorectal canal was patent, and admitted a No 28 F catheter.

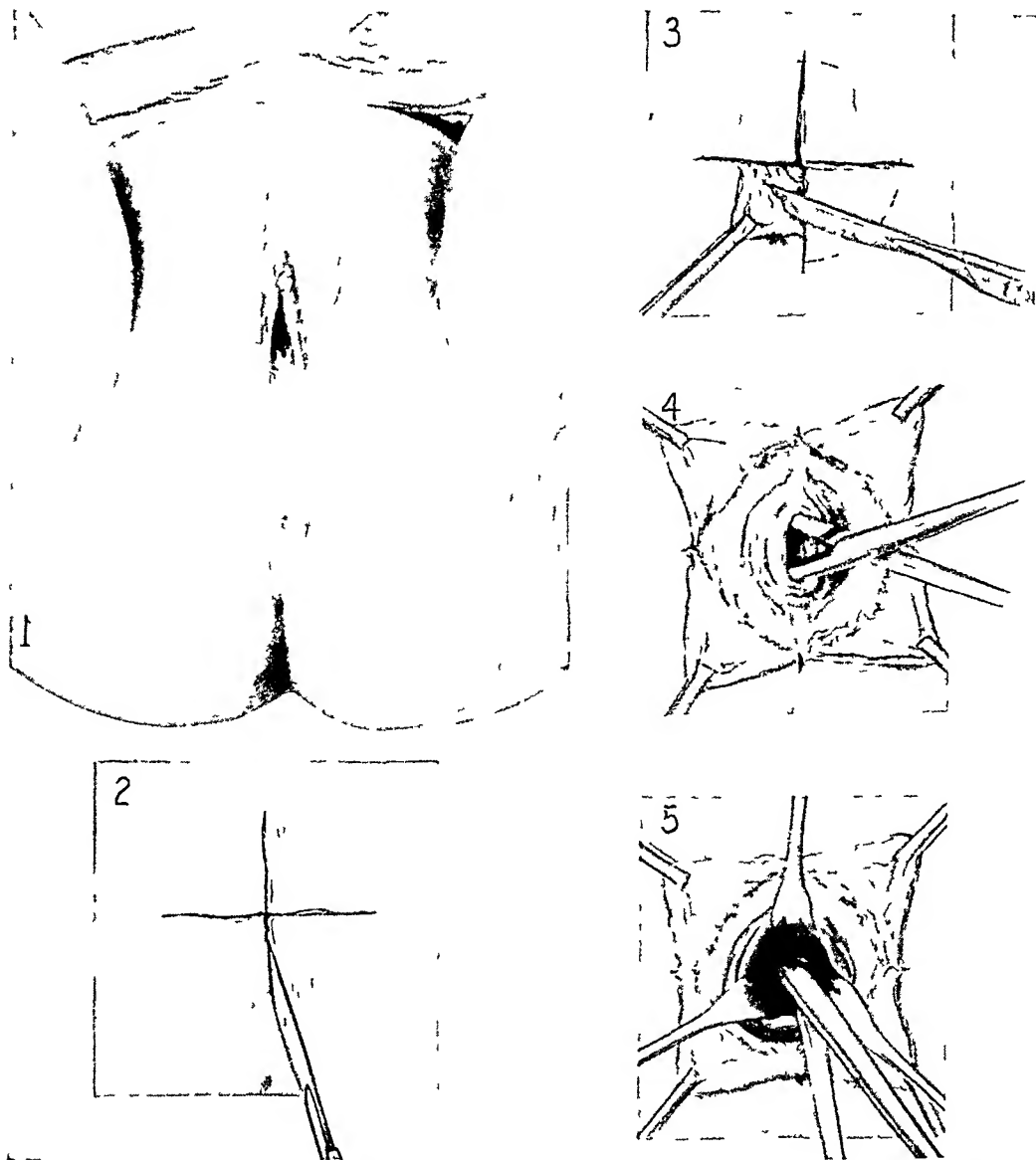


FIG 2—(1) Appearance of perineum before operation (2) Line of incision (3) Dissection of skin flaps (4) Blunt dissection of sphincter (5) Creation of intrasphincteric tunnel

The skin flaps had remained *in situ* in three places, and epithelization between the flaps had occurred. The area where the one flap had become detached was a smooth fibrous area which, no doubt, would have epithelized later.

Pathologic Examination—*Gross* The entire gross specimen was sectioned by Col Eugene Whitmore of the Department of Pathology at Georgetown University Medical School, to whom I am indebted for the sections which showed

(1) There was continuity between skin and mucosa in over seven-eighths of the circumference of the newly constructed anorectal canal

RECTAL MALFORMATION

Fig 3—Creation of fibromuscular canal through pelvic structures by blunt dissection

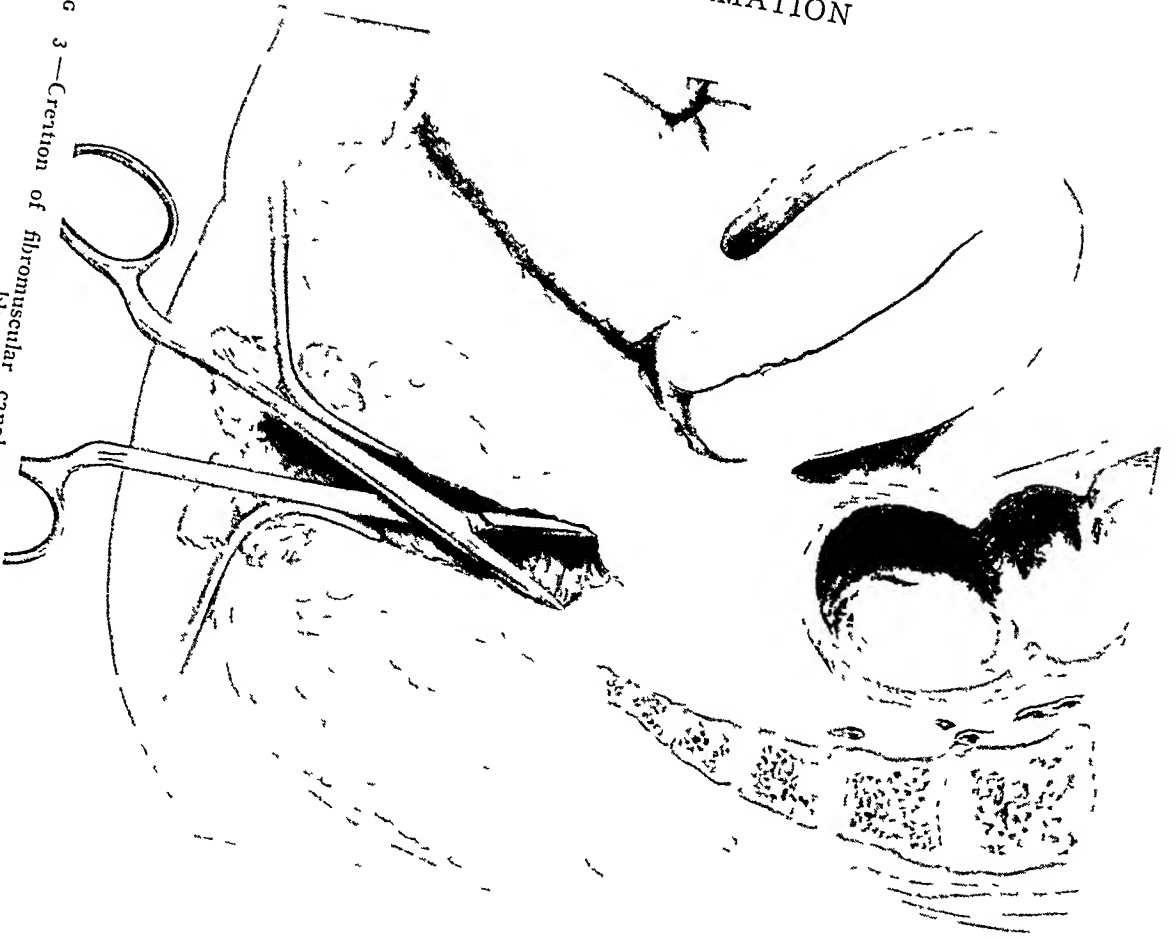
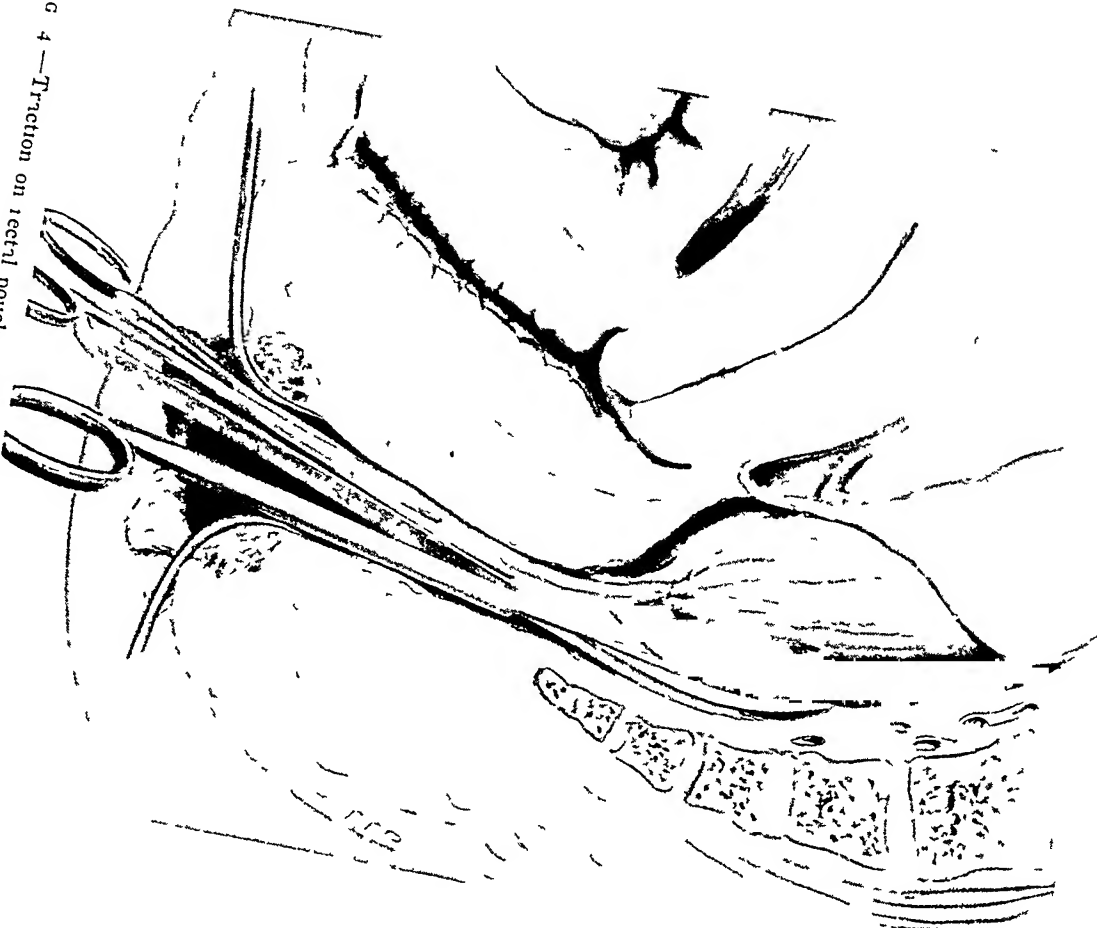


Fig 4—Traction on rectal pouch with blunt scissor dissection of posterior and lateral wall necks



(2) The fibrous tissue incident to the amount of work done was of a moderate amount

(3) The sphincter muscles were in their normal position at the anal orifice and appeared to be of normal size and histologic structure

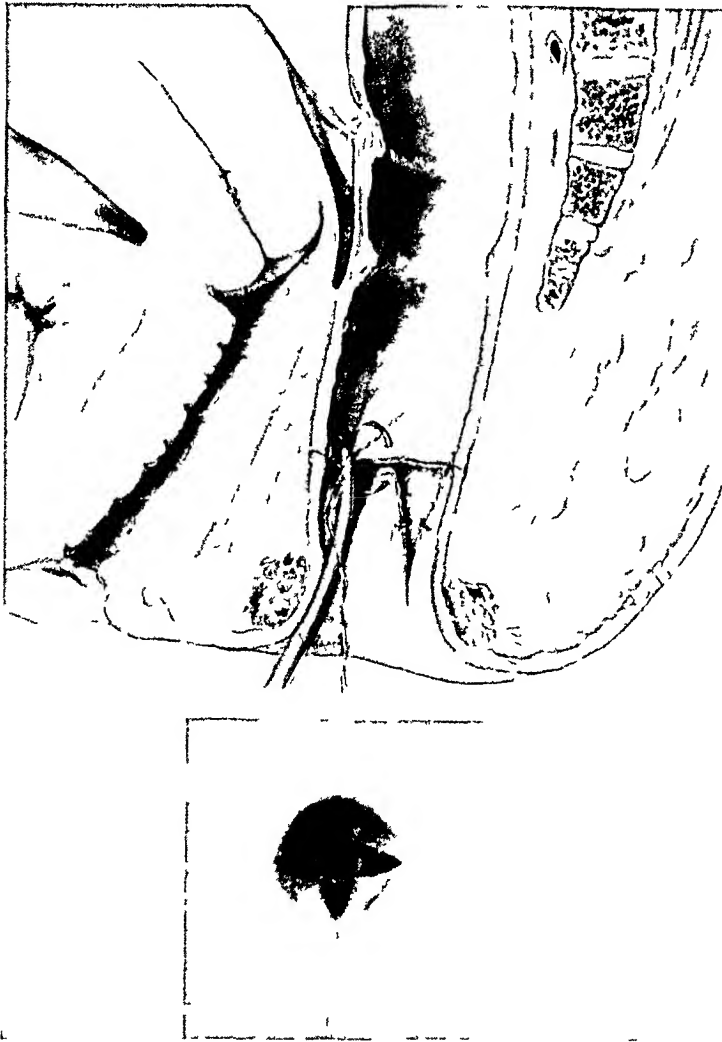


FIG 5—Rectum mobilized and brought down as far as possible. Suture of skin flap to lower edge of rectum. Insert shows appearance from below.

Discussion—In discussing this case in particular, it is seen that here we had a congenital defect that would fall into Type III of Ladd and Gross.² It is felt that these authors have advanced the most recent acceptable method of classification, as far as it pertains to treatment. In this group, the rectal pouch may end a variable distance from the anus. If it is low and can be mobilized by dissecting upward along its posterior and lateral margins, it may be brought down and sewn directly to perianal skin. Continuity of skin and mucosa is established and the formation of a fibromuscular canal lined with mucosa is assured. This is important, as failure to establish continuity of epithelial surfaces tends to fibrous tissue contracture and stricture formation. Recurrent stricture, requiring long and continued periods of dilation, occurs in

cases in which an unlined fibrous tissue canal has been formed. However, if the rectal pouch is high, or it cannot be mobilized and brought down to skin by a perineal approach, it is usually necessary to perform a colostomy. In Ladd's series of 117 cases of Type III abnormality, 99 had perineal operations attempted. Of these, 85 (86 per cent) were successful. The remainder necessitated the formation of a colostomy. Abdominal operation and colostomy has, in the past, been the procedure of choice when the rectal pouch was too high to be brought down after a perineal approach. The mortality of an abdominal operation that follows a perineal operation has been close to 100 per cent. These infants usually cannot stand two operations, *i e*, perineal and abdominal.

This type of case is one in which colostomy alone, or unsuccessful perineal operation followed by colostomy, has usually been done. If the child lived with a functioning colostomy, the anorectal abnormality remained uncured unless corrected at some later date.

The author apologizes for reporting only one case treated as outlined. However, this is a preliminary report on a series of cases treated by various procedures. In a field where no single individual's experience is great, it is felt that the operative technic presented, even if slightly modified, may be of some value. This should be particularly true in cases where the rectal pouch cannot be brought down to skin level.

SUMMARY

A single case of congenital absence of the anus and lower rectum is reported. The value of preoperative roentgenologic studies, to locate the level of the rectal pouch, is illustrated by this case. Furthermore, it is felt that while positive roentgenologic findings may be conclusive as to the level of the rectal pouch, negative findings should call for repeated studies.

A new technic of operative procedure is presented, which appears to increase the scope of perineal approach.

The structural utility of the operation is confirmed by the autopsy findings.

It is hoped that the method may be of some value to others confronted with the choice between colostomy and perineal operation.

REFERENCES

- ¹ Berman, J. K. Congenital Anomalies of the Rectum and Anus. *Surg., Gynec. and Obstet.*, 66, 11, 1938.
- ² Ladd, Wm. E., and Gross, Robert E. Congenital Malformation of the Anus and Rectum. *Amer. Jour. Surg.*, 23, 167, 1934.
- ³ Wangenstein, O. H., and Rice, C. O. Imperforate Anus—A Method of Determining the Surgical Approach. *Amer. Jour. Surg.*, 92, 77-81, 1930.

CHRONIC HYPERTENSION PRODUCED BY CAROTID SINUS AND AORTIC-DEPRESSOR NERVE SECTION†

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HERING'S DEMONSTRATION¹ of acute hypertension in various animals, especially the rabbit, after bilateral section of the carotid sinus and aortic-depressor nerves, was followed by his inquiry into the possibility of producing chronic hypertension by the same means. The results of his investigation were only partially successful. His pupils, Koch and Mies,² in 1929, employing rabbits, with a slight variation in technic, reported more substantial hypertensive results, ranging from 125 to 178 Mm of mercury over a period of months (maximum of 511 days). In 1931, Koch³ observed the production of chronic hypertension of several months' duration by similar means in dogs. In the same year, Heymans and Bouckaert⁴ published their first series of studies on chronic hypertension in dogs, reporting values as high as 250 Mm of mercury. In 1933, Kiemer, Wright and Scaiff⁵ confirmed Koch and Mies's observations in the rabbit, observing elevations of pressure between 120 and 190 Mm of mercury, 80 per cent of the cases registered between 150 and 190 Mm. Dautiebände,⁶ in 1934, recorded three dogs with pressures of 190 to 220 Mm of mercury, in his studies on the pharmacologic and chemical properties of the carotid sinus nerve.

A reconsideration of Koch's earlier work led him and his co-worker, Mattonet⁷ to recant his original claims of chronic duration of the hypertension obtained by carotid sinus and aortic-depressor denervation. Green, DeGroat and McDonald⁸ also reported essentially negative results after section of these afferent pathways.

The writer began this investigation, in 1934, on dogs, resorting to the Hering technic as modified by Heymans†

METHOD—Twenty dogs were studied. Ether or intravenous nembutal (0.5 cc of 6 per cent solution [Abbott] per kilo) were used for anesthesia. In 13 of these dogs bilateral denervation was accomplished in one stage according to the Hering-Heymans technic. This consisted of excising both common carotid bifurcations with the intervening plexus constituting the carotid sinus nerve and by resecting one to two centimeters of the aortic-depressor nerve in the vagal sheath (Fig 1). In one dog, the effect of unilateral excision of the carotid bifurcation and aortic-depressor nerve was studied.

* Aided in part by a grant from the Permanent Charity Fund of Harvard Medical School. Submitted for publication January 10, 1939.

† This technic and the results of Heymans' investigation, were personally observed, in his laboratory in Ghent, by the author over a period of a year.

In three dogs, "pure denervation" was attempted by leaving the carotid bifurcation intact, resecting the carotid sinus plexus with careful removal of all macroscopic evidence of nerve structures including the adventitia in this region, and by excision of the aortic-depressor nerve in the neck as described above

Damage to the internal carotid artery during this procedure, in one dog, necessitated excision of the bifurcation after pure denervation of the other side. This dog developed hypertension and was grouped with the first series.

The anemic effect of excising the carotid bifurcations and leaving the aortic-

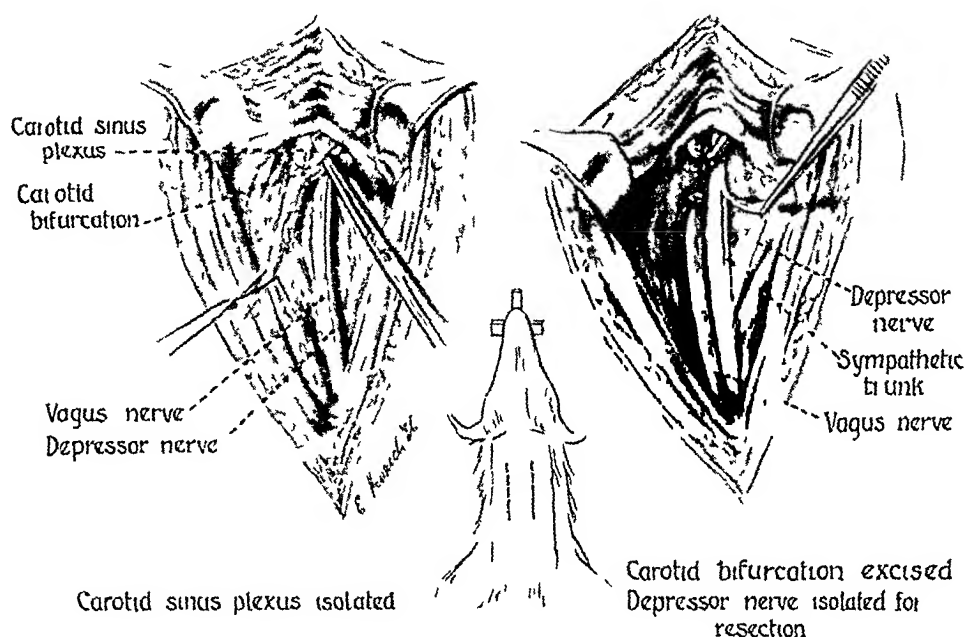


FIG. 1.—The Hering Heymans method for carotid sinus exclusion and aortic depressor nerve section

depressor nerves intact was studied in one dog. It was further investigated by ligating the external and internal carotid arteries in two dogs. This procedure left the carotid sinus nerve plexus undisturbed.

Identification of the aortic-depressor nerve is unquestionably the most difficult part of the denervation. In some cases it stands out as a definite, fine white strand at the level of the carotid bifurcation lying within the vagal sheath in the groove between the cervical sympathetic trunk medially and the vagus trunk laterally (Fig. 1). In doubtful cases, Kridman's⁹ method of identification of the nerve is very helpful. He observed that the nerve is formed by two or three fine strands at the junction of the superior laryngeal and vagus nerves which unite into a single strand and which continues its peripheral course as described above.

In several doubtful cases, stimulation of the cranial end of one of these strands was employed to observe cardiac slowing or hypotension but this test

could not be relied upon consistently. Its chief value lay in identifying the cervical sympathetic trunk which responds to stimulation by marked ipsilateral exophthalmos.

Blood pressure readings were accomplished by direct arterial puncture with a No. 19 or 20-gauge, intravenous needle with appropriate manometric connections for kymographic recording, 25 per cent magnesium sulphate being used as anticoagulant. The dogs were immobilized on their backs on an animal board and were observed for any unusual excitement during the process of blood pressure registration. In several cases the possible exciting effect of this procedure was studied by recording the heart rate by means of a modified Boas cardi tachometer before and during the blood pressure registration. Pressures were taken at about fortnightly intervals. One control blood pressure was usually taken, although in several dogs two to four readings were obtained when the initial pressure appeared unusually high. The dog's diet consisted of cooked meat, milk, bread and water. The animals were kept in cages and were exercised only by being allowed to run about the room once a day for a short time.

RESULTS—Control Blood Pressure and Heart Rates in Dogs In this series of dogs the predenervation blood pressures obtained by direct femoral arterial puncture varied from 100 to 162, averaging 130 Mm. of mercury. The heart rates ranged from 92 to 170, averaging 124.

Effect Upon the Heart Rate of Direct Puncture of the Femoral Artery for Blood Pressure Determination The response of the heart rate to this procedure was used as an index of a possible exciting effect and consequently false hypertensive registration. In Dog 23, for example, the control heart rate as recorded by the Boas cardi tachometer was 115 per minute. Insertion of the needle into the artery caused absolutely no change in the heart rate while the blood pressure reading was 214 Mm. of mercury.

Criteria for Hypertension While greater significance should be attached to relative changes in blood pressure, certain criteria are obviously necessary for gauging the results as a whole. On the basis of an average blood pressure of 130 Mm. of mercury, it was decided to establish 180 Mm. as a minimum hypertensive requisite. The required minimal duration was taken as six months. One dog (No. 15) was included with a hypertensive period of four and one-quarter months, however, because death occurred under an anesthetic prior to splanchnic section, after a consistently maintained average arterial tension of 213 Mm. of mercury.

Effect of Bilateral Carotid Bifurcation Excision and Aortic-Depressor Nerve Resection on Blood Pressure (Hering-Heymans Technique) Of the 13 dogs denervated by this method, seven developed definite chronic hypertension (Chart 1 and Table I). Four dogs showed only transient or no hypertension, and two died within four days after denervation.*

* Since submission of this article for publication three more dogs with hypertension have been added to this series, making a total of 10 chronic hypertensive dogs out of 16 attempts.

CHRONIC HYPERTENSION

Marked elevation of arterial pressure was observed as early as two days after this type of denervation. Thus Dog 9, whose control pressure was 124 prior to denervation, showed an increase to 184 two days later. In Dog 7, the pressure rose from a control level of 158 to 190 on the third day. In general, the blood pressure became definitely elevated within two to three

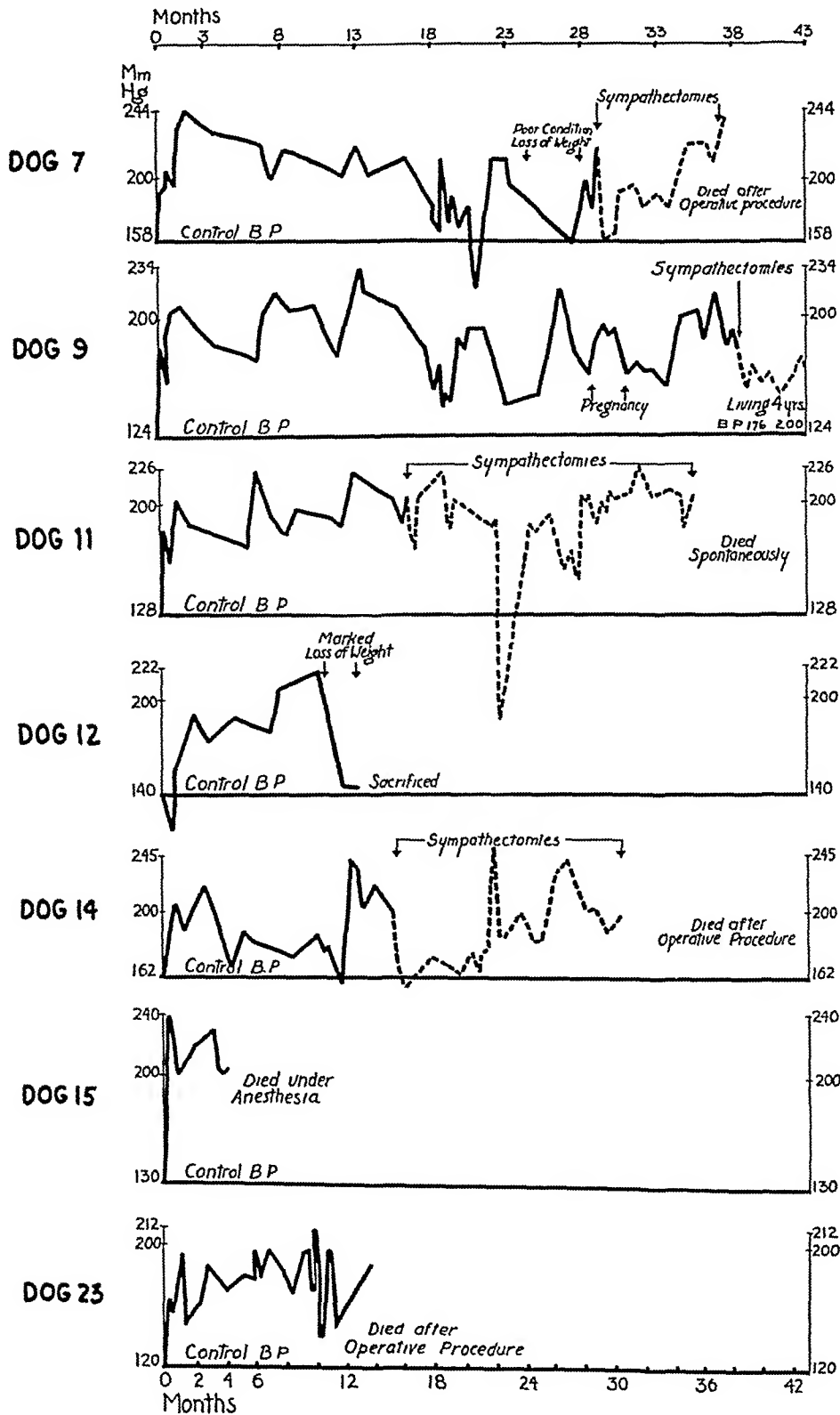


CHART 1—Blood pressures in dogs with chronic hypertension produced by carotid sinus and aortic depressor denervation (Details of sympathetic procedures will appear in a subsequent communication) Blood pressures brought up to date to show longevity of hypertension

TABLE I

SUMMARY OF BLOOD PRESSURES AND HEART RATES IN DOGS WITH CHRONIC HYPERTENSION
PRODUCED BY CAROTID SINUS AND AORTIC-DEPRESSOR DENERVATION

Dog No	Sex	Control B P and H R		Maximum B P Corre- sponding H R	Minimum B P Corre- sponding H R	No B P Deter- mina- tions	Per Cent B P Readings over 180 Mm	Final B P and H R	Duration of Hyper- tension in Months
7	M	B P 158 Mm H R 155		B P 244 Mm H R 174	B P 156 Mm H R 150	52	67	B P 240 Mm H R 96	38—Opera- tive proce- dure fatal
9	F	B P 124 Mm H R 140		B P 234 Mm H R 228	B P 140 Mm H R 150	50	60	B P 190 Mm H R 192	39—Living*
11	M	B P 128 Mm H R 170		B P 226 Mm H R 222	B P 112 Mm H R 136	53	74	B P 202 Mm H R 146	36—Died spontane- ously
12	F	B P 140 Mm H R 110		B P 222 Mm H R 228	B P 114 Mm H R 180	11	55	B P 146 Mm H R 132	10—Sacr- ficed at 13 months Con- dition poor B P low
14	M	B P 162 Mm H R 136		B P 245 Mm H R 156	B P 154 Mm H R 138	38	68	B P 202 Mm H R 150	30¼—Op- erative pro- cedure fatal
15	M	B P 130 Mm H R 96		B P 244 Mm H R 216	B P 197 Mm H R 186	7	100	B P 204 Mm H R 186	4¼—Died of anesthesia
23	M	B P 120 Mm H R 94		B P 212 Mm H R 77	B P 142 Mm H R 83	26	54	B P 190 Mm H R 96	13¼—Op- erative pro- cedure fatal

* Died at 48½ months after operative procedure with final blood pressure of 186 Mm Hg

weeks after denervation. These findings are in agreement with those observed in the rabbit by Kremer, Wright and Scarff.⁵ The maximum reading obtained was 245 Mm of mercury in Dog 14.

Effect of Unilateral Carotid Bifurcation Excision and Aortic-Depressor Nerve Resection on the Blood Pressure. Unilateral (left) excision of the carotid bifurcation and depressor nerve in the neck in one dog resulted in hypertension (210-190 Mm of mercury) of seven and one-half months' duration, with return to about normal after this interval.

Fluctuations of Blood Pressure and Known Factors Associated with Such Fluctuations. Fluctuations in arterial tension were observed in the rabbit by Koch and Mies, and by Kremer, Wright and Scarff, and also in the dog by Heymans and Bouckaert.¹⁰ In Dogs 11 and 15, the blood pressure readings showed practically no fluctuations (Chart 1 and Table I). Known factors associated with fluctuations may be stated as follows:

(a) *Regeneration or Incomplete Denervation.* In two dogs, which failed to develop definite chronic hypertension after the Hering-Heymans operation, experiments were carried out to examine evidence of the aortic-depressor nerves due to regeneration or incomplete removal. The possible presence of the aortic-depressor nerves was determined by section of the vagi, below the

region of resection and by cephalad faradic stimulation at this point. In one of these dogs (No. 19), bilateral vagotomy caused the blood pressure to rise temporarily from 150 to 216 Mm. of mercury, in another dog (No. 16), there was a slight rise from 114 to 140 Mm. In the latter dog there was evidence of a depressor reaction (118 to 74 Mm.) upon faradic stimulation of the left vagus.

(b) *Debility and Loss of Weight* Dog 12 began to lose weight from severe cachexia 10 months after denervation. During the ensuing three months the blood pressure dropped to 146 after a persistent level of 182 to 222 Mm. of mercury. Recovery seemed unlikely and the dog was sacrificed.

Dog 7 also became cachectic 14 months after denervation with a drop to normal over a period of six months, after which, however, the blood pressure rose concomitantly with clinical improvement.

(c) *Pregnancy* Dog 9 became pregnant 29 months after denervation. Prior to this time the blood pressure curve was quite variable with an upward trend before pregnancy so that the effect of the latter was difficult to evaluate. The blood pressure, however, rose further from 186 to 196 and dropped abruptly to 160, 10 days before termination of pregnancy (Chart 1). This part of the blood pressure readings can, in fact, be duplicated in other sections of the curve where spontaneous elevations and depressions were even more marked. The significant feature would appear to be absence of a striking hypertensive effect of pregnancy.

Duration of Hypertension The shortest duration in this hypertensive series was four and one-quarter months (Dog No. 15), death occurring accidentally under anesthesia prior to an operative procedure. The longest survival was in Dog 9, with a hypertensive duration of three years and three months. (This dog is still alive after unilateral thoraco-abdominal sympathectomy with a final blood pressure of 200 Mm. of mercury, four years after denervation.)

Heart Rate In general, denervation was followed by a marked and sustained augmentation of the heart rate. In practically all the dogs the acceleration varied almost directly with the blood pressure (Table I). In four dogs (Nos. 9, 11, 12 and 15) the maximum blood pressure readings showed correspondingly maximum heart rates. In three dogs (Nos. 7, 14 and 23) this relationship did not hold.

Dog 9 illustrates the parallelism with a maximum blood pressure of 234 Mm. of mercury and corresponding maximum heart rate of 228 per minute (Chart 2). Dog 7 shows the dissociation of these two factors with a blood pressure of 220 Mm. of mercury and heart rate of 130 per minute (Chart 2).

That adrenal secretion plays a definite rôle in the tachycardia in some of these animals, and a contributory rôle in others, was shown by diminution in the heart rate after bilateral adrenal inactivation or unilateral removal and contralateral inactivation. These findings will be discussed in detail in a subsequent communication.

Blood Counts, Cell Volume, Blood Gases, Blood and Urine Chemistry

Blood counts, cell volume, oxygen and carbon dioxide content and capacity of the blood were within normal limits. Examination of carbohydrate, protein, fat, chloride and calcium content of the blood revealed no deviation from the normal. Urinalysis was also not remarkable except for a slight amount of sugar and moderate albumen.

Effect of Denervation of the Carotid Sinus Leaving the Bifurcation and Branches Intact with Excision of the Aortic-Depressor Nerve in the Neck—"Pure Denervation" This procedure was employed in three dogs, all of which failed to develop definite hypertension. Thus Dog 16, the control pressure of which was 117 Mm of mercury, showed an increase of tension to 162 in two

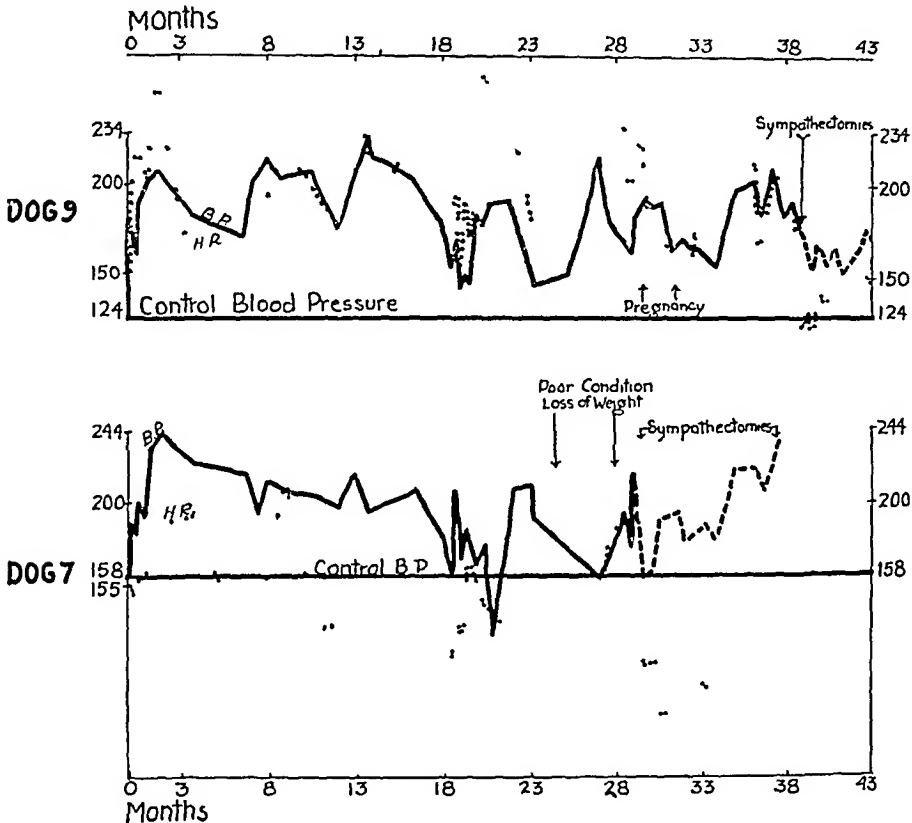


CHART 2—Blood pressures and corresponding heart rates in dogs with chronic hypertension produced by carotid sinus and aortic depressor denervation

weeks followed by a drop to the control level and a later return to 154 Mm of mercury two months after denervation. It is of interest that subsequent bilateral excision of the carotid bifurcations also failed to induce hypertension.

Dog 17, starting with a blood pressure of 146 Mm of mercury, responded to pure denervation by a gradual rise to 172, four months after denervation, but returned to 143 Mm eight months after denervation.

Dog 18 showed a rise from a control pressure of 144 Mm of mercury to 166, three days after denervation and a decline to 154 Mm at the end of one month. Excision of both carotid bifurcations subsequently failed to produce hypertension.

Effect upon Blood Pressure of Excision of the Carotid Bifurcation and of

Ligation of the Branches of the Carotid Bifurcation In Dog 19, the control blood pressure of which was 116 Mm of mercury, the carotid bifurcations were excised in one stage. The maximum pressure observed after this procedure was 146 Mm of mercury six weeks later. Seven and one-half months later it was 108 Mm of mercury. It is of interest that bilateral depressor nerve section at this time also failed to produce hypertension. The highest pressure recorded was 144 Mm of mercury, six weeks after this section.

In two dogs, the branches of the carotid bifurcation were ligated. The results in these dogs were as follows. In Dog 20 the blood pressure rose sharply from a control level of 150 to 197 Mm of mercury in the first week, after which it showed variations and a gradual return to 158 Mm of mercury in four months. Dog 29 showed a rise from a control pressure of 142 to 179 Mm of mercury, this level has been maintained to date over a period of three and one-half months. Thus the anemic effect of exclusion of the carotid bifurcation or its branches with respect to the blood pressure response is a variable one. When the effect is hypertensive it was not permanent except in one dog which was only recently operated upon.

DISCUSSION—The recantation of Koch,⁷ and the negative results of Green, DeGroat and McDonald⁸ have raised serious doubts as to the accuracy of the findings of the workers who have reported chronic hypertension by carotid sinus and aortic-depressor denervation.

Examination of Koch and Mattonet's⁷ results on four dogs, all of which failed to maintain their original hypertension, shows that at least two manifested evidence of depressor nerve activity by a rise in pressure (125 to 185 Mm) after bilateral vagotomy in the terminal experiment. The other two dogs showed slight rises in pressure after the same procedure. In the face of these indications of incomplete denervation or regeneration, their work cannot be considered conclusive.

The possibility of incomplete denervation or regeneration might also be considered in the technic employed by Green, DeGroat and McDonald.⁸ In order to assure complete chronic denervation of the carotid sinus nerve, excision of either arterial branch of the carotid bifurcation or the bifurcation itself has been practiced by most workers. The technic of Green and his co-workers leaves the bifurcation and its branches intact. Employing a similar technic, referred to above as "pure denervation," the writer was unable to produce definite hypertension in three dogs, and in this respect is in agreement with these workers but failure to obtain hypertension was ascribed to incomplete denervation. Our control experiments on the anemic effect of carotid bifurcation excision and of ligation of the branches of the bifurcation, although variable, appeared to rule out anemia as a factor in this hypertension. It is impossible to say, however, whether this degree of anemia might not sensitize the effect of carotid sinus and aortic-depressor denervation.

On the other hand, terminal studies carried out in two of our four failures, operated upon by the Hering-Heymans' technic, showed evidence of some

degree of depressor nerve response upon stimulating the cranial end of the cut vagus nerve. It cannot be stated that the amount of depressor activity observed was sufficient to account for the lack of hypertension. It is conceivable that other afferent pathways were operating in these dogs to neutralize the hypertensive effect of the denervation.

Fluctuations in blood pressure readings have already been described by previous workers. In three of the seven hypertensive dogs the fluctuations were marked, reaching normal values frequently over a period of weeks. As discussed in the results, inanition was undoubtedly the cause of this remission in two dogs, while in the third no apparent cause could be found. In two of these dogs hypertension was reestablished. Insistence on a sustained high arterial tension, although met with in two of our dogs, is an exacting demand in the light of clinical hypertensive experience.

The absence of abnormal chemical changes in the blood carbohydrate, protein, fat, chloride, calcium, oxygen and carbon dioxide argues against the possibility of chemohumoral basis for the hypertension produced by this method. The lack of disturbance in the cell volume rules out blood viscosity as a factor. On the other hand the investigations of Hering,¹ Koch and Mies,² Heymans and Bouckaert,¹¹ and Nowak^{1,2} show that the hypertension resulting from carotid sinus and aortic-depressor denervation is chiefly neuroconstrictive.

SUMMARY

(1) Chronic hypertension was produced in ten dogs by carotid bifurcation excision and cervical aortic-depressor nerve resection.

(2) The maximum duration of hypertension was three years and four months.

(3) Fluctuations in arterial tension were observed in the majority of these dogs. Inanition was definitely responsible for marked remission of hypertension in two dogs.

(4) Failure to produce chronic hypertension by this method occurred in four dogs. In two of these animals, in which terminal experiments were carried out, there was evidence of some degree of aortic-depressor nerve activity.

(5) The anemic effect of excising the carotid bifurcations are discussed.

(6) "Pure denervation," preserving the vessels of the carotid bifurcation, failed to produce lasting hypertension in three dogs.

(7) Unilateral (left) denervation produced hypertension in one dog of seven and one-half months' duration, with final return to normal level.

(8) Pregnancy did not alter appreciably the course of hypertension in one dog.

(9) Persistent tachycardia was a common finding after denervation. Its degree varied directly with the blood pressure readings in most instances. Maximum blood pressure readings were correlated with maximum heart rates in about one-half the cases.

(10) There were no changes in the blood carbohydrates, proteins, fats, chlorides, calcium, oxygen, carbon dioxide, cell volume and red cell counts

(11) Urinalyses were also essentially normal

BIBLIOGRAPHY

- ¹ Hering, H E Die Karotissinusreflexe auf Herz und Gefasse vom normal-physiologischen, pathologisch-physiologischen und klinischen standpunkt Dresden, Th Steinkopff, 1927
- ² Koch, E and Mies, H Krankheitsforschung, 7, 241, 1929
- ³ Koch, E Ergebnisse der Kreislaufforschung Band I, Th Steinkopff, Dresden, 1931
- ⁴ Heymans, C, and Bouckaert, J J Compt rend Soc de biol, 106, 471, 1931
- ⁵ Kremer, M, Wright, S, and Scarff, R W Brit Jour Exper Path, 14, 281, 1933
- ⁶ Dautrebande, L Calif and West Med, 40, 145, 1934
- ⁷ Koch, E, and Mattonet, K Ztschr f d ges exper med, 94, 105, 1934
- ⁸ Green, M F, DeGroat, A F, and McDonald, C H Am Jour Physiol, 110, 513, 1935
- ⁹ Kreidman, A Archiv f Anat u Physiol, 1, 405, 1878
- ¹⁰ Heymans, C, and Bouckaert, J J Bull Acad Roy Med Belg, 1, 42, 1936
- ¹¹ Heymans, C, and Bouckaert, J J Arch internat de pharmacodyn et de therap, 48, 191, 1934
- ¹² Nowak, S J G Compt rend Soc de biol, 115, 1731, 1934
Idem Arch internat de pharmacodyn et de therap, 60, 129, 1938

PHEOCHROMOCYTOMA

CASE REPORT

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AND

MEYER O CANTOR, M D

DETROIT, MICH

WE have been accustomed to think of tumors as being either malignant or benign, the chief points of differentiation being based upon the question of the spread of the tumor through distant metastases or by the extension to contiguous structures. This differentiation, obviously is based upon anatomic considerations. From this point of view, one would be forced to consider the pheochromocytomata benign tumors. Interestingly enough, several very recent text-books describe this tumor type as "a rare tumor which is innocent, small, well encapsulated, and may be found by accident at autopsy in elderly persons."

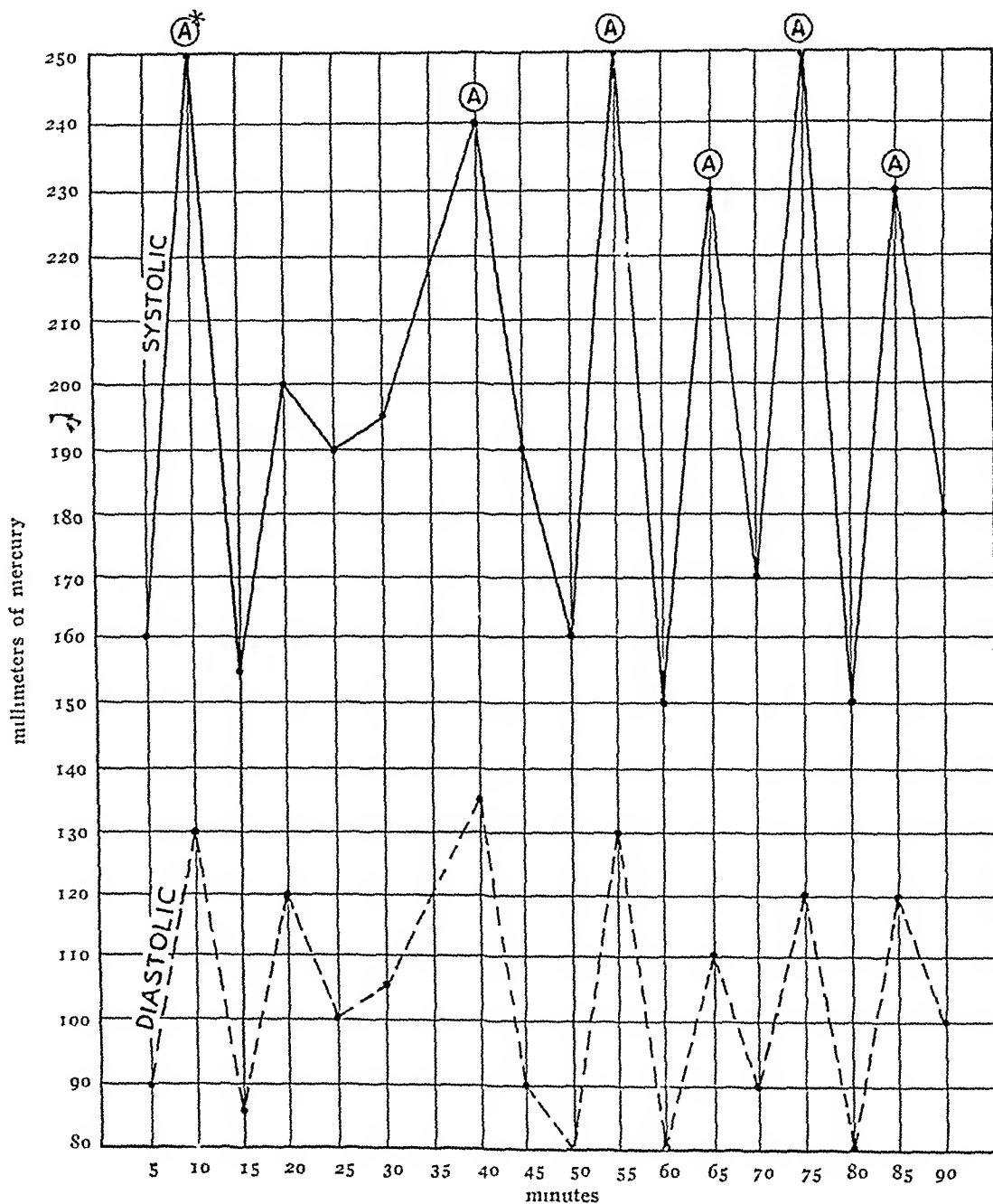
An increasing number of case reports within the last few years have demonstrated, conclusively, that this tumor type is not the "innocent" tumor it was thought to be. The hypertension which many writers have described as being an incidental finding in such cases has been proven to be due to the tumor. These pheochromocytomata characteristically produce attacks of elevated blood pressure, paroxysmal in nature. The paroxysmal hypertension acting over a period of time results in the arteriolar sclerosis which ultimately results in death to the patient.

For this reason we prefer to consider this type of tumor as benign anatomically but malignant physiologically. It is the physiologic activity of this tumor that is malignant and not its anatomic consideration. Being composed of adrenal medullary tissue, the attacks of paroxysmal hypertension are generally conceded as being due to the temporarily increased output of epinephrine. The symptoms associated with the attacks of hypertension are those commonly found as a result of an overdose of epinephrine, namely, palpitation, cold clammy extremities, pallor, nervousness and dizziness. Because of the infinitesimally small amount of epinephrine normally found in the circulating blood (1 to 100,000,000),¹ it is apparent that attempts to measure this increase have been unsuccessful. Kalk² has demonstrated, however, 375 mg to 500 mg of epinephrine in a tumor of this type, whereas the normal adrenal is said to contain only 4.22 mg of epinephrine.

From what has been said, it becomes apparent that many of the cases of the so-called "essential hypertension," which in the early stages are described as having paroxysmal elevations of blood pressure, may very likely be due to

chromaffinomata Certainly, it is the duty of the surgeon to investigate this carefully in the 20- to 40-year-old group, with a view to recognizing cases of this type of tumor and removing them before irreparable damage is done to the cardiovascular system as a result of the hypertension It is in this age

CHART I



* At points "A" dizziness, cold clammy extremities, tremor, and pallor occurred

group that the results of surgery are indeed brilliant Coller³ reports the case of a male, age 25, with the pathognomonic fluctuations of blood pressure, in whom the classic tumor was found at operation A complete cure resulted, and a normal future was substituted for one of impending death due to damaged vessels in the heart, kidneys or brain The opposite side of the picture is presented in our case report which shows the end-results of this type of

tumor, which was permitted to remain until the cardiovascular system was so extensively damaged that a cure was impossible

Case Report—H P, white, adult male, was first seen by one of us (E C B) July 9, 1928. At this time he complained of tiredness and headaches. These had been rather troublesome during the past three years, but not to such a degree as to interfere with his work. With these attacks of headache he would complain of dizziness, cold sensations, "goose-flesh," and nervousness. There was no nausea or vomiting associated with the headaches which were diffuse over the entire cranium. No blurring of vision or spots before eyes. No ataxia. His appetite was good.



FIG 1.—Drawing showing the position of the adrenal medullary tumor springing from the loose tissue over the convex border of the right hydronephrotic kidney. It was not attached to the kidney directly.

Physical Examination—The only deviation from the normal was a systolic blood pressure of 160 and a diastolic of 100 Mm of mercury. His urine on this occasion was negative for albumin and signs of kidney damage. Kahn test was negative.

He was advised to return to the office at monthly intervals for a check-up of his blood pressure. During the next six years his blood pressure was found to fluctuate between 250 and 130 Mm mercury systolic and 130 to 90 Mm mercury diastolic. During the periods of high blood pressure he would complain of nervousness, coldness, and dizziness. In the intervals between attacks his blood pressure would range from 130 to 145 Mm mercury systolic and 80 to 90 Mm mercury diastolic. The most interesting feature of these attacks was the suddenness of onset and the marked fluctuations during the interval of 90 minutes. On many such occasions we would leave the sphygmomanometer

cuff on his arm and take blood pressure readings at five-minute intervals. We would then find the blood pressure to rise from 145/90 to 250/130 many times during an hour's time (Chart 1).

The patient continued then, from 1928 to 1937, with these periodic attacks of paroxysmal hypertension and the associated dizziness, nervousness, and headaches until January 3, 1937. On this date, while sitting, he was suddenly seized with a very severe pain in the left chest. This was so severe that he was unable to move. It was sharp and shooting in character and radiated to the left back and down the left arm. It was of three minutes' duration and was accompanied by a marked fear of impending death. He was admitted to the Evangelical Deaconess Hospital, with a diagnosis of coronary occlusion. This diagnosis was verified electrocardiographically. Death occurred suddenly on his sixth hospital day.

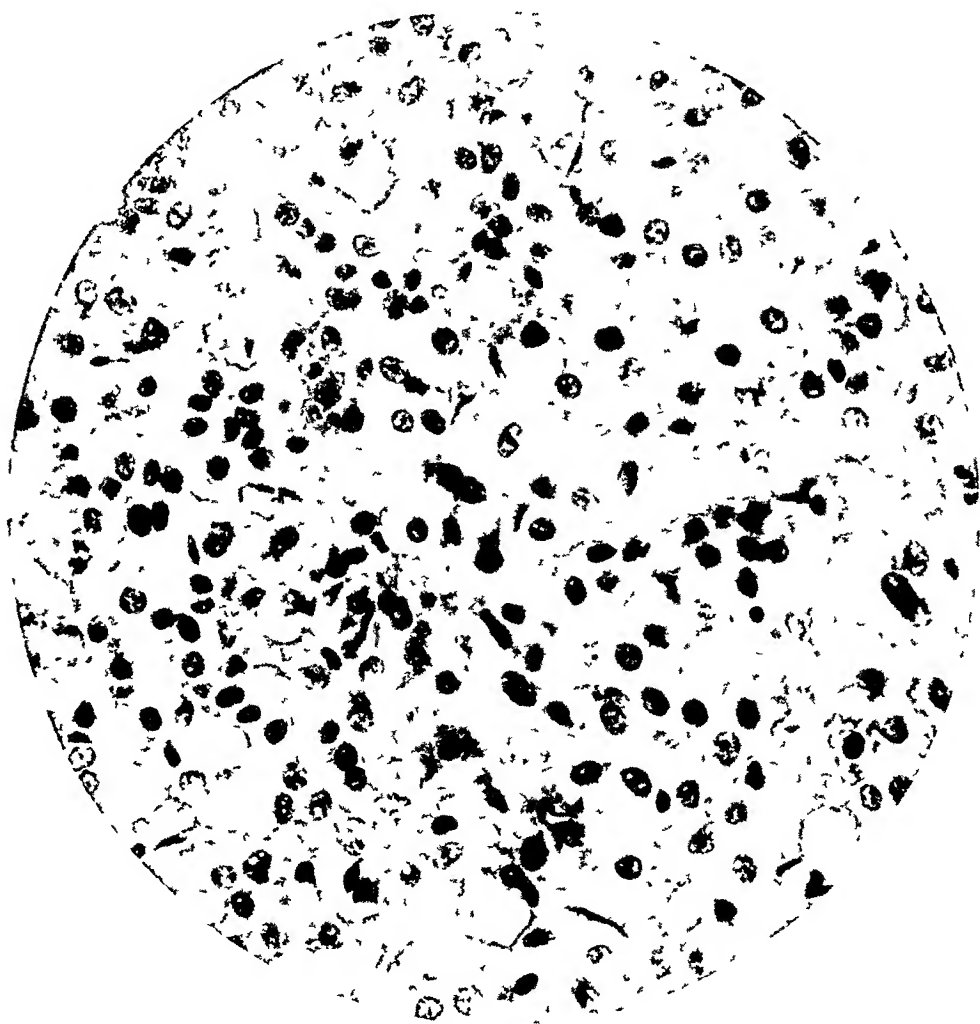


FIG 2—Section taken from tumor attached to convex border of kidney (X950)

Autopsy—The pertinent findings were: Heart enlarged, but not markedly. Complete occlusion of the descending branch of the left coronary artery. Necrosis of the interventricular septum. Coronary sclerosis.

A walnut-sized tumor mass was found attached to the loose areolar tissue over the convex, lateral surface of the right kidney about midway between its poles (Fig 1). It was firm, and derived its blood supply from the areolar tissue it was imbedded in and not from the kidney. On section, a soft pale yellowish surface was seen.

Microscopic examination of tumor revealed the anastomosing cords of very deep staining epithelial cells separated by numerous thin-walled sinusoids. Many of the cells appear to be multinucleated (Fig 2). *Pathologic Diagnosis*—Adrenal medullary tissue—chromaffinoma (Dr P. F. Morse).

COMMENT —This case presents the typical course taken by a patient with a chromaffinoma (pheochromocytoma). During its early stages, we find the pathognomonic attacks of paroxysmal hypertension with the associated symptoms of dizziness, pallor, nervousness, and cold clammy extremities, which are generally conceded as being due to hyperepinephrinemia. Then, later in life, we find the arteriolar sclerosis which is the result of the unchecked hypertension. In this particular individual the small vessel sclerosis showed a marked predilection for the coronary arteries, with a resultant typical coronary occlusion—and death. The cardiac, neurologic, and renal consequences of the hypertension are the same in all types of continued high blood pressure regardless of cause. When these changes have become marked, treatment is hopeless. The time to attack this problem is at the beginning when the paroxysmal attacks of high blood pressure first make their appearance. It is these attacks that are pathognomonic of a pheochromocytoma.

It is important to remember that since the tumor may appear on the right or left side, consequently, if at operation over the right adrenal no tumor is found, the left adrenal area should then be explored.

CONCLUSIONS

(1) This case presented the typical picture of a pheochromocytoma which was permitted to run its course without interference.

(2) This course is. Paroxysmal attacks of hypertension, then, as a result of the continued high blood pressure, the cardiac, neurologic, or renal consequences become manifest due to the small vessel sclerosis. The typical coronary occlusion was the mode of exodus in this case.

(3) Diagnosis may be made solely upon the pathognomonic attacks of the paroxysmal hypertension.

REFERENCES

- ¹ Barr, P. D. Recent Advances in Endocrinology. J A M A, 105, 1760, November 30, 1937.
- ² Kalk, H. Paroxysmale Hypertension. Klin Wchnschr, 13, 613, April 28, 1934.
- ³ Coller, F. A., Field, H., and Durant, T. M. Chromaffin Cell Tumor Causing Paroxysmal Hypertension. Arch Surg, 28, 1136, June, 1934.

A MODIFIED FORM OF LUMBAR SYMPATHECTOMY FOR DENERVATING THE BLOOD VESSELS OF THE LEG AND FOOT, ANATOMIC CONSIDERATIONS

A PRELIMINARY REPORT

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J. C. WHITE^{1, 2} has recently propounded the hypothesis that the therapeutic value, in cases of arterial disease of the lower extremity, of removing the second, third, and fourth lumbar ganglia depends to a great extent on leaving the sacral ganglia intact. Ascroft's³ work lends weight to this hypothesis. By removing the sacral ganglia, he has been able to destroy the beneficial effects of a previously satisfactory lumbar sympathectomy. This work was carried out on monkeys. By virtue of leaving the sacral ganglia undisturbed, a predominantly preganglionic denervation of the blood vessels of the foot is obtained. In this manner, the sensitization of arteriolar musculature to circulating adrenaline which follows destruction of its postganglionic innervation^{4, 5, 6, 7, 8, 9, 10} is avoided, and the denervated arterioles in the foot remain dilated. It occurred to me that removing the lumbar ganglia might be an entirely superfluous procedure, and that it might be possible to achieve the desired therapeutic result, in properly selected cases, by merely sectioning the lumbar sympathetic trunk at an appropriate level.

Figure 1 indicates diagrammatically the way in which the sympathetic vasomotor and sudomotor fibers are supposed to reach the lumbosacral plexus,^{1, 11} within the branches of which they are distributed to the blood vessels and sweat glands, respectively, of the lower extremity.¹² The diagram and its legend are self-explanatory. However, there are several points to which I should like to draw particular attention.

- (1) There are four lumbar ganglia and not five.
- (2) This reduction in number is theoretically brought about by the fusion of the ganglia sending gray rami to the fourth and fifth lumbar spinal nerves.
- (3) Interruption of the trunk between the third and fourth lumbar ganglia, as indicated at (a) in Figure 1, should theoretically destroy all preganglionic neurones forming synapses with postganglionic neurones to spinal nerves L 4, 5, S 1, 2, and 3. In this manner, the blood vessels and sweat glands receiving their postganglionic sympathetic innervation through these spinal nerves would be denervated, and the denervation would be entirely preganglionic.

The blood vessels thus denervated would be the popliteal artery and its branches through the sciatic nerve, and the cutaneous vessels of the foot and leg through L 4, 5, S 1, 2. It was felt that since the extent of such a denervation would be quite adequate for the treatment of a large number of cases of arterial disease involving the lower extremity, a lumbar sympathectomy modified in this manner would be of value for two reasons

- (1) It should be extremely simple and easy to perform, thus widening the field of application of lumbar sympathectomy in the treatment of peripheral arterial disease
- (2) By leaving the lumbar ganglia *in situ*, as much of the sympathetic innervation of the lower bowel, bladder, and reproductive apparatus as can possibly be saved will be preserved. This is an important consideration since bilateral lumbar ganglionectomy performed in men may produce sterility

Accordingly, it was decided to attempt such a denervation in the following case, by dividing the lumbar sympathetic trunk at the upper pole of the fourth lumbar ganglion, treating the divided ends to prevent regeneration, and leaving the ganglia themselves undisturbed

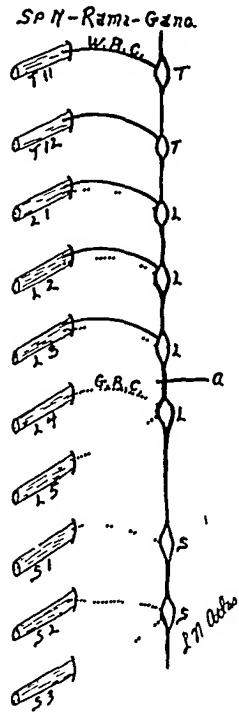


FIG 1—W R C Preganglionic neurones from 1 11 12, L 1, 2 and 3 carrying vasomotor and sudomotor impulses and form synapses with G R C Post ganglionic neurones which are distributed to blood vessels of lower extremity via L 1, 2, 3 4 5 S 1 2 and 3 Sp N Spinal nerves Rami Rami communicantes Gang Sympathetic ganglionated trunk T Thoracic, L Lumbar, S Sacral (a) Shows point at which trunk was divided in first operation, see text and Figure 2 (Based on information drawn from White¹ and Gask and Ross¹¹ and Potts¹²)

Case Report—Hosp No 186118 A C, white female, age 31, was referred to the Peripheral Vascular Clinic of the Cleveland City Hospital from the Lowman Pavilion, where she is being treated for pulmonary tuberculosis. Fourteen years previously, her fingers started to turn blue and white on exposure to cold or during emotional upsets, and she would perspire profusely. Seven years later, a severe atrophic arthritis developed in her fingers resulting in extreme deformity. Five years ago, she noticed that her feet would also become cyanotic on exposure to cold or during emotional upsets, accompanied by increased perspiration. Recently, an atrophic type of arthritis had started to involve her toes.

Physical Examination—The patient was very apprehensive and nervous. Her hands and feet were markedly cyanotic, covered with perspiration and cold to the touch. Both hands were markedly deformed. There was also an early arthritis deformans involving several of the toes. Pulsation in the dorsalis pedis and posterior tibial arteries was palpable. Under a spinal anesthetic, and at a room temperature of 23° C, skin temperatures, taken from various points on the feet, rose from 21.0°–23.5° to 33.2°–34.2° C. In view of the possible connection between the obvious vasospasm and the subsequent development of the arthritic process, it was decided to abolish the vasospasm in the feet by means of a lumbar sympathectomy, hoping, thereby, to arrest the progression of the joint disease.

Operation—Through a right-sided, muscle splitting retroperitoneal approach, described by Pearl,¹³ the fourth lumbar ganglion was located. The sympathetic trunk was divided at the upper pole of the ganglion, both ends were ligated with silk, and the

proximal end buried in the adjacent psoas muscle. As anticipated, the operation was easily and quickly performed.

Subsequent Course—The next day the patient presented a very interesting picture. The right inferior extremity below the knee was hot and dry to the touch with the exception of a patch of skin around the internal malleolus which extended down the inner border of the foot. This patch was cold and covered with sweat.

A week later, the left lumbar sympathetic trunk was similarly severed at the upper pole of the fourth lumbar ganglion. The next day, the patient presented the same picture as existed on the right except the extent of the undenerivated zone was even more striking and could be easily mapped out (Fig 2). It is seen to embrace the cutaneous distribution of the terminal fibers of the saphenous nerve. Segmentally, this zone is L 4.

Unable to account for the fact that the vasomotor and sudomotor fibers distributed through the fourth lumbar nerve had been left intact, provided the schema as portrayed in Figure 1 was anatomically correct, I was led to reexamine the manner in which the lumbar ganglia are connected with the lumbar spinal nerves.

Anatomic Research—For the purpose of the study, 31 lumbar sympathetic trunks were dissected in the Anatomical Laboratory of Western Reserve University. Since the dissections were gross, it is possible that in some instances very fine rami were not defined. However, I am confident that all the major communications and the important accessory ones were found.

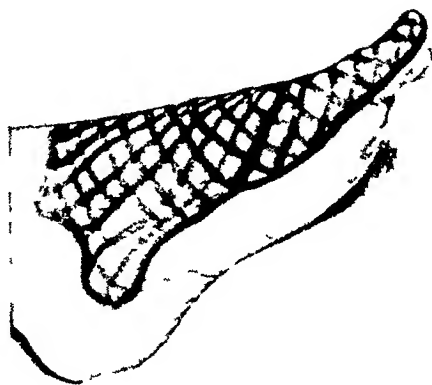


FIG 2—Cross hatching shows extent of undenerivated region remaining after division of lumbar sympathetic trunk at point (a) in Figure 1. Note similarity to zone of distribution of saphenous nerve in foot which is L 4 segmentally.

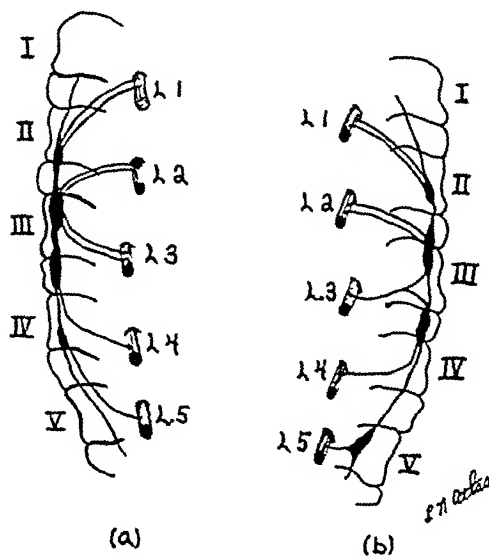


FIG 3—Two variations in topographic anatomy of the lumbar sympathetic ganglia and their connections with the lumbar spinal nerves. (Drawn from original dissections in Anatomical Laboratory of Western Reserve University.)

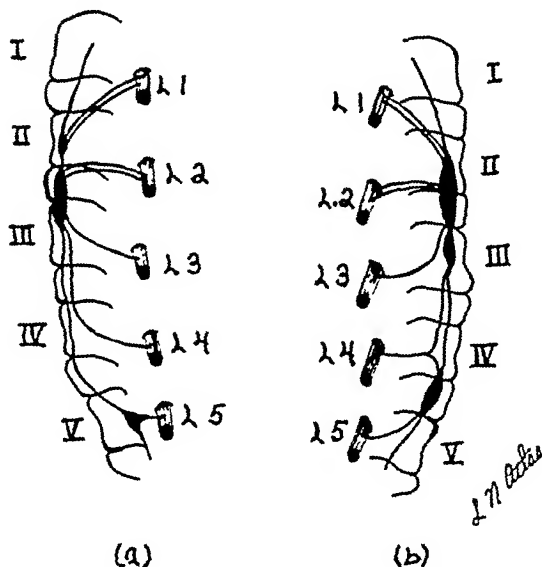


FIG 4—Two variations in topographic anatomy of the lumbar sympathetic ganglia and their connections with the lumbar spinal nerves. (Drawn from original dissections in Anatomical Laboratory of Western Reserve University.)

There were no instances, save one, in which more than four lumbar ganglia were present. In the exception, there were five, due to a reduplication of the ganglion connected with the fourth lumbar nerve (Fig 5 b). However, there were many instances in which further fusion had reduced the number to three. The nature of these fusions will be discussed in detail below.

The first lumbar nerve was constantly connected with the highest lumbar ganglion by two major rami (Figs 3b, 4a, and 5a). This ganglion rested on the second lumbar vertebra and was occasionally overlapped by the intermediate crus of the diaphragm. Its connections with the first lumbar nerve left the ganglion in a cephalad direction. At times it was incompletely fused (Fig 3a), or completely fused (Fig 4b), with the proximal pole of the ganglion just distal to it, namely, that connected with the second and third lumbar nerves.

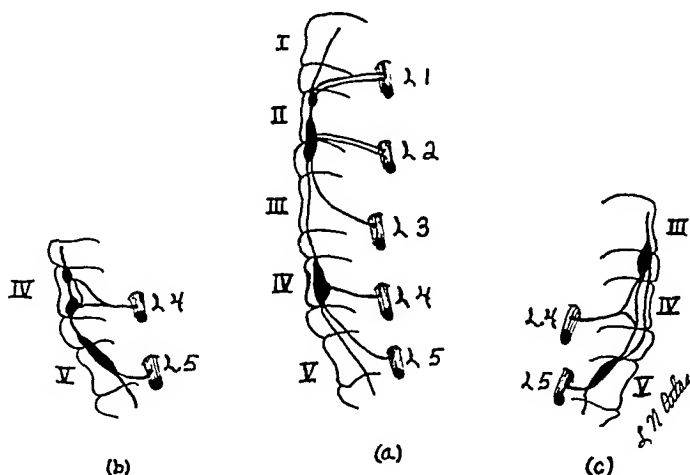


FIG 5—Three variations in topographic anatomy of the lumbar sympathetic ganglia and their connections with the lumbar spinal nerves. (Drawn from original dissections in Anatomical Laboratory of Western Reserve University.)

The second and third lumbar nerves had their major connections in every instance with a *single* ganglion (Figs 3, 4, and 5a). The second nerve was connected by two major rami which usually made their exit from the ganglion in a cephalad direction. The third nerve was connected by a single major ramus which usually left the ganglion in a caudad direction. It was often joined by an accessory branch from the ganglion connected with the fourth lumbar nerve (Fig 3b). Only once was the third nerve connected by two major rami. The position of the ganglion was fairly constant. It rested at the edge of the psoas muscle on the second lumbar intervertebral disk and the bodies of the vertebrae (L 2 and 3) adjacent to it. It was consistently the largest of all the ganglia. The ganglia connected with the first and fourth lumbar nerves were at times partially or completely fused with its upper and lower poles, respectively.

The connections of the fourth lumbar nerve were variable. In 16 instances it was connected with a distinct ganglion having no major connections with any of the other lumbar nerves (Fig 3a). In one of these instances the

ganglion was split (Fig 5b) In 12 instances the fourth nerve was connected with a ganglion which was either partially fused (Figs 3a and 4b), or completely fused (Fig 4a), with the lower pole of the ganglion connected with the second and third lumbar nerves In only three instances was it fused with the ganglion connected with the fifth lumbar nerve (Fig 5a) The connection with the fourth lumbar nerve consisted of a single major ramus, which usually left the ganglion in a caudal direction, and which was on several occasions joined by an accessory branch from the ganglion connected with the fifth lumbar nerve (Figs 4b and 5c) Lying at the edge of the psoas major muscle, the position of the ganglion was otherwise variable In 12 instances it was located on the third lumbar vertebra, in 14, on the third lumbar intervertebral disk, and in five, on the fourth lumbar vertebra When on the third lumbar vertebra, it was partially or completely fused with the lower pole of the ganglion connected with the second and third lumbar nerves in every instance save one When on the third lumbar intervertebral disk, it was separate and distinct in every instance except one When on the fourth lumbar vertebra, it was separate and distinct in two instances and fused with the ganglion connected with the fifth lumbar nerve in three

The fifth lumbar nerve was connected by a single major ramus to the most distal of the lumbar ganglia In 21 instances, this ganglion had no connection with any other lumbar nerve (Figs 3a and b, 4a and 5b) In seven instances, it sent an accessory branch cephalad to join the major ramus to the fourth lumbar nerve (Figs 4b and 5c) In only three instances were the fifth and fourth lumbar nerves connected with the same ganglion (Fig 5a), which, in every instance, was located on the fourth lumbar vertebra at the edge of the psoas muscle In one other instance, the ganglion was located on the fourth lumbar vertebra, in six, on the fourth lumbar intervertebral disk, and in 21, on the fifth lumbar vertebra When on the last lumbar vertebra, it was often completely overlapped by the psoas major muscle, covered by a dense layer of fascia, and in close proximity to the fifth lumbar nerve I am convinced that in a large number of lumbar ganglionectomies, the fourth ganglion is never seen, and that what is considered to be the last is really the third

One of the results of this study is that certain concepts concerning the topographic anatomy of the lumbar sympathetic ganglia and their connections with the lumbar spinal nerves must be revised The requisite changes are portrayed diagrammatically in Figure 6 The diagram and its legend are self-explanatory

In addition, it was evident that severing the lumbar sympathetic trunk on the body of the *third* lumbar vertebra would accomplish one of two things, depending on the anatomic disposition of the ganglia

- (1) If the ganglion connected with the fourth lumbar nerve is separate and distinct, all the preganglionic fibers to blood vessels innervated through L 4, 5, S 1, 2, and 3 would be destroyed The point of division is at (a) in Figure 6

- (2) If there is a fusion of the ganglia connected with L 2, 3, 4, then the postganglionic fibers to blood vessels innervated through L 4, and the preganglionic fibers to the blood vessels innervated through L 5, S 1, 2, and 3 would be destroyed. The point of division is at (b) in Figure 6

Either way, the undenervated area corresponding to the segmental cutaneous innervation from L 4, encountered in the reported case, would be avoided. In addition, it has been my experience that exposing the trunk on the third lumbar vertebra often reveals the accessory connection of the trunk with the third lumbar spinal nerve. These can also be divided giving an absolutely complete denervation of all the blood vessels below the thigh.

The question arises whether a lumbar sympathectomy modified in this manner, that is, by dividing the lumbar sympathetic trunk on the body of the third lumbar vertebra, dividing its accessory connection with the third lumbar spinal nerve, and managing the divided ends to prevent regeneration, would have any appreciable advantage over the usual ganglionectomy. I believe it will prove to be of value as an alternative procedure to be used.

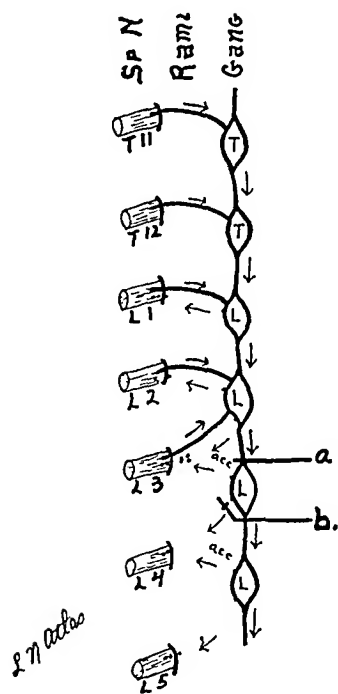


FIG 6—Diagrammatic schema of connections of the lumbar spinal nerves with the lumbar sympathetic ganglia based on dissection of 31 lumbar sympathetic trunks. Note changes from Figure 1. Note constant fusion of ganglia connected with L 2 and 3 to reduce the number of lumbar ganglia to four. Further fusion as described in the text may reduce total number of lumbar ganglia to three.

Acc Accessory postganglionic ramus

Arrows indicate flow of vasomotor and sudomotor impulses. This flow may be interrupted at either (a) or (b) by dividing the trunk on the body of the third lumbar vertebra.

- (1) When the risk of producing sexual disturbances from a bilateral denervation must be reduced to a minimum.
- (2) When technical difficulties encountered at the time of operation render exposure of the ganglion connected with the second and third lumbar spinal nerves so difficult as to render an attempt to remove it inadvisable. Difficulty in exposing this ganglion is not infrequently encountered in obese individuals, and in instances of inadequate relaxation from a poorly administered anesthetic. Reference to Figure 6 will indicate why the removal of the ganglion connected with the second and third lumbar spinal nerves, and only this ganglion, is necessary if all the vessels in a lower extremity are to be denervated. In fact, unless

this ganglion is removed, resection of the more distal ones can accomplish no more than merely division of the trunk on the third lumbar vertebra without disturbing any of the ganglia.

- (3) On poor surgical risks or elderly individuals where operative manipulation is to be kept at a minimum.

- (4) When a denervation limited to the blood vessels of the foot and leg will suffice

Up to the present time, I have found occasion to employ this modified form of lumbar sympathectomy in 27 instances. In every case, the extent of the denervation obtained was equal to that anticipated. In some of the earlier cases, where the accessory connection of the trunk with the third lumbar spinal nerve was overlooked, only partial denervation of the cutaneous vessels

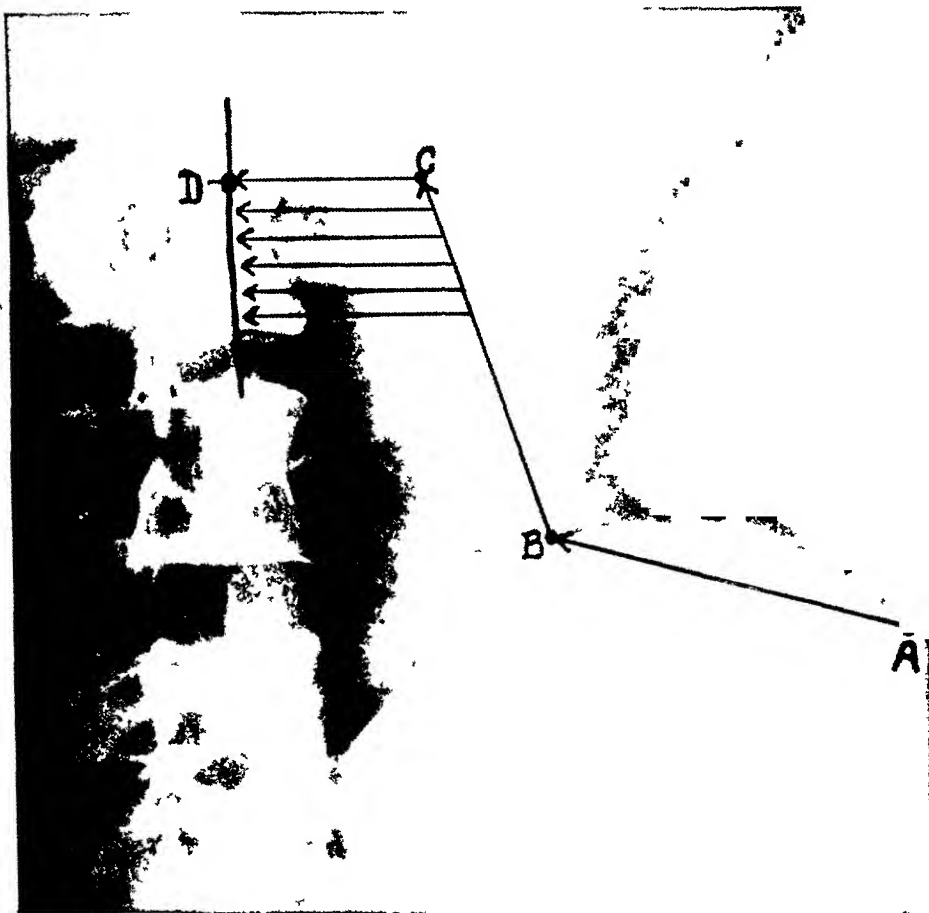


FIG 7—Illustrates the technic employed to expose the lumbar sympathetic trunk on the body of the third lumbar vertebra through a muscle splitting retroperitoneal approach

in the upper half of the leg was obtained. This was probably due to an overlapping of segmental cutaneous innervation from L 3. A bilateral operation in a male, age 42, did not produce any disturbance of sexual function. Some of these individuals have been observed for over a year, and in none has any diminution in the extent or magnitude of the denervation, which could be attributed to regeneration been encountered.

Operative Technic—The following technic is employed to expose the lumbar sympathetic trunk on the third lumbar vertebra. A roentgenogram is made before the operation in order to show the relationship of the crest of the ilium, the lateral margin of the psoas major muscle, and the third lumbar vertebra. The muscle splitting retroperitoneal approach described by Pearl is preferred, using 150 mg of novocain intrathecally as the anesthetic. This

approach is quickly and easily performed, it is remarkably free from shock or postoperative reaction, and gives excellent exposure of the third lumbar vertebra. When the retroperitoneal space is opened, the crest of the ilium is immediately palpated, at point A in Figure 7. The retroperitoneal tissues are dissected from the crest of the ilium until the lateral edge of the psoas major



FIG 8—Roentgenogram taken on seventh postoperative day showing silver clips on cut ends of sympathetic trunk. Clip opposite fifth lumbar vertebra is point at which distal end is buried in psoas muscle. Clip on third lumbar vertebra is point of division. Included in this clip is divided accessory ramus to third lumbar nerve at point where ramus dips backward between vertebra and psoas muscle.

muscle is reached at the point where it crosses the crest, at point B in Figure 7. The lateral edge of this muscle is then exposed in a cephalad direction until a point is reached opposite the upper border of the third lumbar vertebra, at point C in Figure 7. The magnitude of this cephalad dissection is equal to the length of line B-C. Further dissection carried medially over the psoas muscle will now expose that portion of the lumbar sympathetic trunk lying on the body of the third lumbar vertebra. The trunk and any accessory parallel

fibers are divided between silk ligatures at the upper limit of the dissection, at point D in Figure 7. The distal portion is then dissected off the body of the third lumbar vertebra. During this stripping process, the accessory connection with the third lumbar nerve is usually broken. The distal cut end is then buried in the adjacent psoas muscle, at point E in Figure 7. The retractors are removed and the patient is instructed to cough. This balloons the peritoneum, obliterating all dead space, and approximates the split muscular layers. The incision is closed in the usual manner. By placing silver clips on the cut ends of the trunk, it is possible to determine by a postoperative roentgenogram at what point the trunk was divided and the point at which the distal end was buried in the psoas muscle. This is illustrated in Figure 8. Note that the distance separating the cut ends is actually much greater than that shown in Figure 7, the latter being purely diagrammatic for purposes of illustrating technic.

REFERENCES

- ¹ White, J. C. *The Autonomic Nervous System*. Macmillan, New York, 1935.
- ² White, J. C. *Progress in Surgery of Autonomic Nervous System*. *Surgery*, 4, 781, November, 1938.
- ³ Ascroft, P. B. *The Basis of Treatment of Vasospastic States of the Extremities. An Experimental Analysis of Monkeys*. *Brit Jour Surg*, 24, 787, 1937.
- ⁴ Meltzer, S. J., and Auer, C. M. *Studies on the "Paradoxical" Pupil Dilatation Caused by Adrenalin*. *Amer Jour Physiol*, 11, 28, 1904.
- ⁵ Freeman, N. E., Smithwick, R. H., and White, J. C. *Reactions of Blood Vessels of Human Extremity Sensitized by Sympathectomy to Adrenalin*. *Amer Jour Physiol*, 107, 529, 1934.
- ⁶ Smithwick, R. H., Freeman, N. E., and White, J. C. *Effect of Epinephrine on Sympathectomized Extremity*. *Arch Surg*, 29, 759, 1934.
- ⁷ Grant, R. T. *Further Observations on the Vessels and Nerves of the Rabbit's Ear, with Special Reference to the Effects of Denervation*. *Clin Sci*, 2, 1, 1935.
- ⁸ White, J. C., Okelberry, A. M., and Whitelaw, G. P. *Vasomotor Tonus of the Denervated Artery*. *Arch Neurol and Psychiat*, 36, 1251, 1936.
- ⁹ McCloskey, K., Co Tui, F. W., Mulholland, J., and Wright, A. M. *Adrenalin Necrosis After Sympathectomy*. *J Lab and Clin Med*, 22, 377, 1937.
- ¹⁰ Atlas, L. N. *Etiology of Vasomotor and Nutritional Changes Following Peripheral Nerve Section*. *Surgery*, 4, 718, November, 1938.
- ¹¹ Gask and Ross. *Surgery of the Sympathetic Nervous System*. Wm Wood, Baltimore, 1937.
- ¹² Potts, L. W. *The Distribution of Nerves to the Arteries of the Leg*. *Anat Anz*, 48, 138, 1914.
- ¹³ Pearl, F. L. *Muscle Splitting Extraperitoneal Ganglionectomy*. *Surg, Gynec and Obst*, 65, 107, July, 1937.

NEW INCISION FOR CLOSED SPACE INFECTION (FELON) INVOLVING DISTAL PHALANX OF FINGER

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FELONS are among the most common infections of the distal phalanx. The ordinary conception of the pathogenesis of bone felons is Roux's theory, in which he claims that the lymphatic vessels run perpendicular from the skin to the periosteum, which is lifted off the bone and necrosis of the bone ensues. Against this assumption is the very firm attachment of the periosteum to the bone. Kanavel¹ contends that pressure of the edema or pus in closed space infections shuts off the blood supply to the bone and causes necrosis. The epiphysis receives a separate blood supply and is therefore, not involved in early cases.

In reviewing the literature on incisions for closed space infections, the three most commonly employed are (A) The midline, (B) fish-mouth, and (C) lateral hockey-stick. Mason,² in his article on infection of the hand, makes the following comments relative to incisions for felons:

(A) A midline incision for felon does not divide the perpendicular connective tissue fibers which attach the skin to the periosteum, the division of which is the essential feature of the operation for drainage of anterior space infections. (B) A fish-mouth incision, while it provides efficient drainage, is followed by a deep furrowed scar which seriously interferes with the use of the finger-tip for the performance of fine acts. Koch³ has also observed that the fish-mouth incision is unduly long in healing and leaves a painful scar over the finger-tip, and also an anesthetic area distal to the scar, which is annoying to anyone attempting to perform delicate manipulations.

(C) The lateral hockey-stick type of incision fulfills the purpose of adequate drainage and does not leave any disabling scars, but does interfere with tactile sensation.

It is with these facts in mind that a new incision is presented, which has been employed for closed space infections, which appears to eliminate the objectionable features of the other incisions. The five illustrations shown in Plate I demonstrate the procedure.

Operative Procedure—First Step Under gas-oxygen anesthesia, the nail is detached from the skin, nail-bed and matrix (Plate I, Figs. 1 and 2).

Second Step An inverted U-shaped incision is made close to the tuft of the bone and part of the shaft of the distal phalanx. The perpendicular fibers are cut close to the bone. The pulp is retracted and the closed space is entered. The abscess is found lying just anterior to the distal phalanx (Plate I, Figs. 3 and 4).

Third Step The mushroom portion of bone is carefully examined for evi-

FELONS

dences of osteomyelitis, and if there are any signs of softening, the tuft is removed (Plate I, Fig 5)
Fourth Step The abscess cavity is evacuated and the necrotic tissue in anterior space, if present, is cut away and the cavity packed with iodoform gauze. Wet dressings of boric acid are applied. The patient is instructed

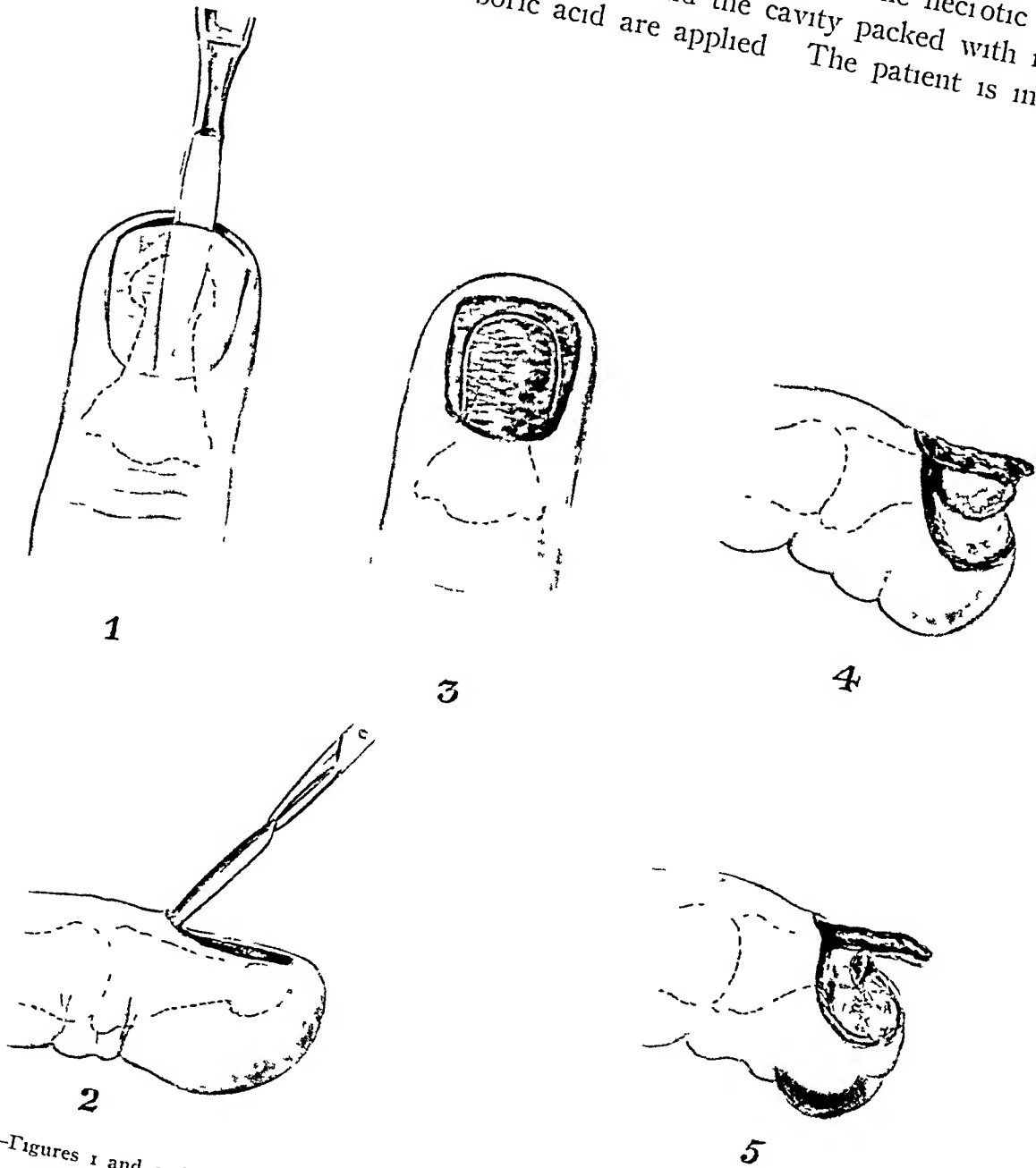


PLATE I—Figures 1 and 2 show the method employed to detach the nail from its bed, matrix and skin attachments of the terminal phalanx. Figures 3 and 4 show the inverted U shaped incision carried down close to the tuft and to distal portion of the terminal phalanx. Figure 5 shows the ample exposure obtained and the resultant gross pathology following removal of the tuft should it have been found to be involved.

to soak the finger in hot boric acid solution every two hours for 20 minutes
The packing is removed in 48 hours
The illustrations accompanying the appended case reports show (1) An early case of closed space infection (2) A case in which the tuft of bone was



FIG 1



FIG 2

FIGS 1, 2 and 3—Case 1 Showing, in sequence (Fig 1) No evidence of bony involvement (Fig 2) One week later still no evidences of osteomyelitis (Fig 3) One month later, still no destruction of the phalanx



FIG 3

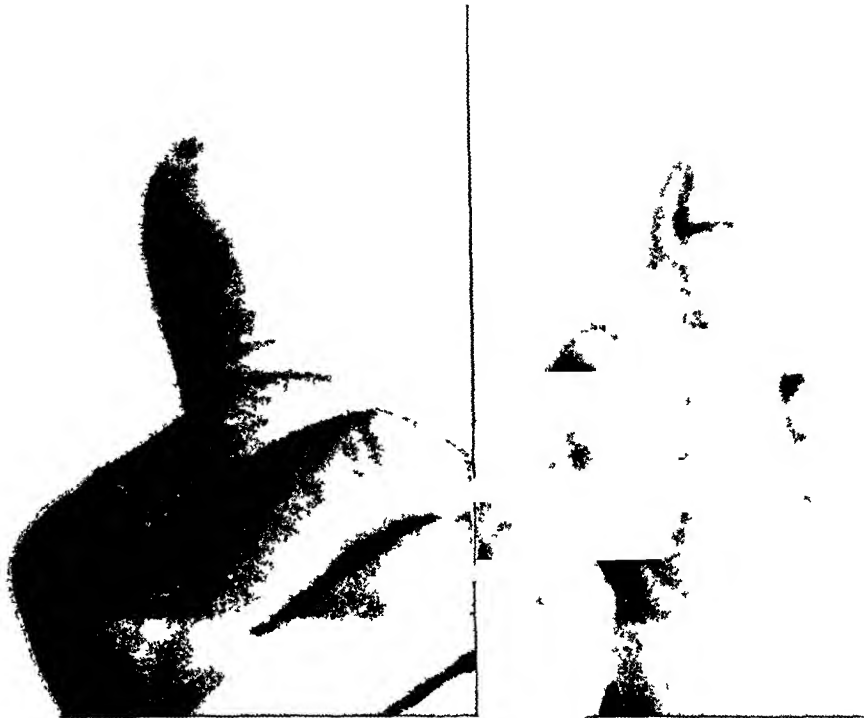


FIG 4

FIG 5

FIGS 4 and 5—Case 1 Show the operative wound entirely healed and a new nail regenerating

involved (3) An instance where the major portion of the phalanx was destroyed, and in which regeneration has taken place

CASE REPORTS

Case 1—A K, male, white, age 30 On June 29, 1939, a wire penetrated his right thumb No attention was paid to it until the thumb began to swell and throb Home

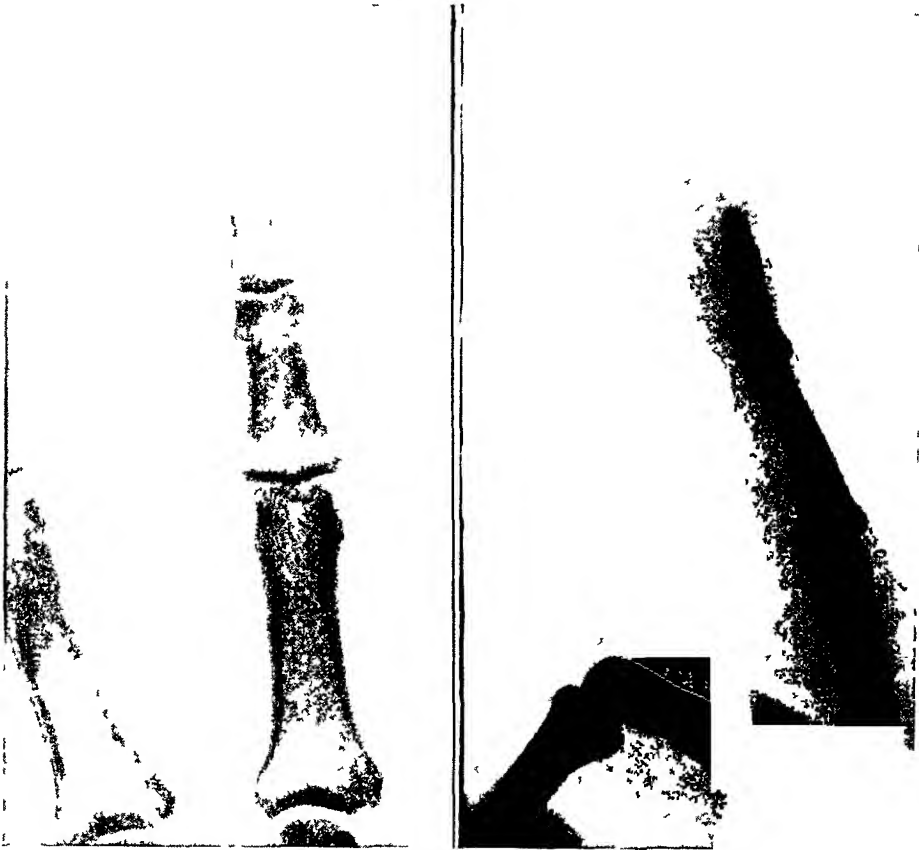


FIG 6



FIG 7

remedies were applied without relief. He was first examined July 7, 1939, one week after the injury. The right thumb was tense, tender and hot, and a small, healed puncture wound was noticed on the volar aspect of the distal portion of the finger. A diagnosis of closed space infection was made. The roentgenogram (Fig 1) revealed no evidences of bony involvement. Under local infiltration with 1 per cent novocain, the thumb was incised as described in the preceding paragraphs. Roentgenograms taken July 14, 1939 (Fig 2), and August 14, 1939 (Fig 3), show no destruction of the phalanx, and photographs taken August 14, 1939 (Figs 4 and 5), show the wound entirely healed and a new nail regenerating.

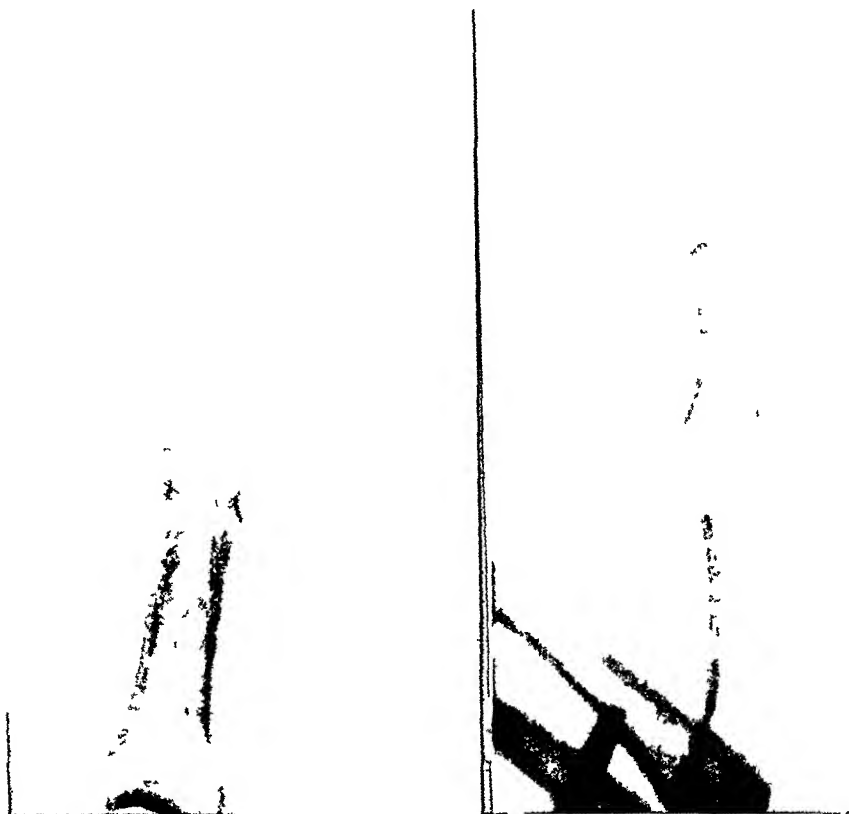


FIG 8

FIGS 6, 7, and 8—Case 2. Showing, in sequence (Fig 6) No evidence of bony involvement. (Fig 7) Ten days later, definite evidences of destruction of the mushroom portion of the distal phalanx. (Fig 8) Five months later complete regeneration of both bone and nail.

Case 2—S. S., female, white, age 28, pricked her left index finger with safety pin March 6, 1939. Very little attention was given it until pain grew very intense. Home remedies were applied without any relief. The condition becoming worse the patient presented herself for examination, March 13, 1939, complaining of pain and swelling of left index finger. The finger was tense, hot, and showed definite evidences of closed space infection. A roentgenogram (Fig 6) showed no evidences of bony involvement. The finger was opened, employing the previously described incision. A roentgenogram taken March 23, 1939 (Fig 7), showed definite evidences of destruction of the mushroom portion of the distal phalanx. One taken August 26, 1939 (Fig 8), shows the bone and nail completely regenerated.

Case 3—J. T., female, white, age 42. Presented herself for examination, March 12, 1939, complaining of throbbing pain in right index finger, stating that she had pricked her finger with a needle, a few days previously. The finger was swollen, red, hot, and showed a puncture wound on the volar aspect, which appeared to have a small pustule at the site of entrance. A roentgenogram revealed no evidences of bony involvement (Fig 9). The finger was opened, employing the previously described incision. A roent-

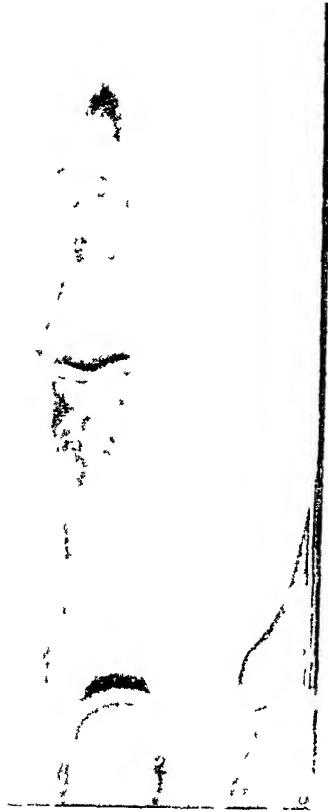


FIG 9

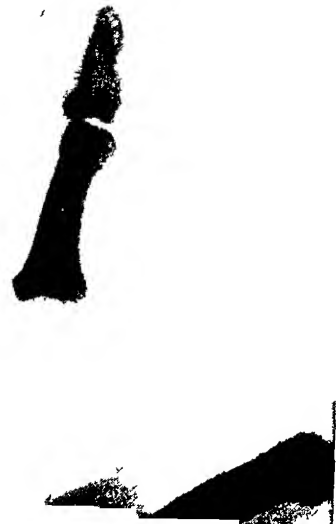


FIG 10
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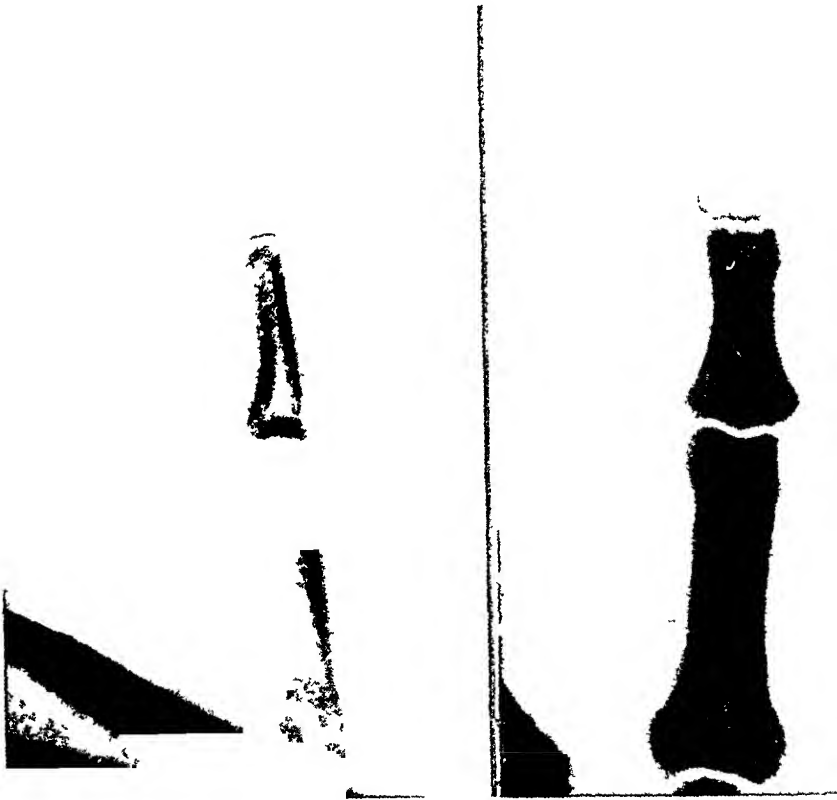


FIG 11

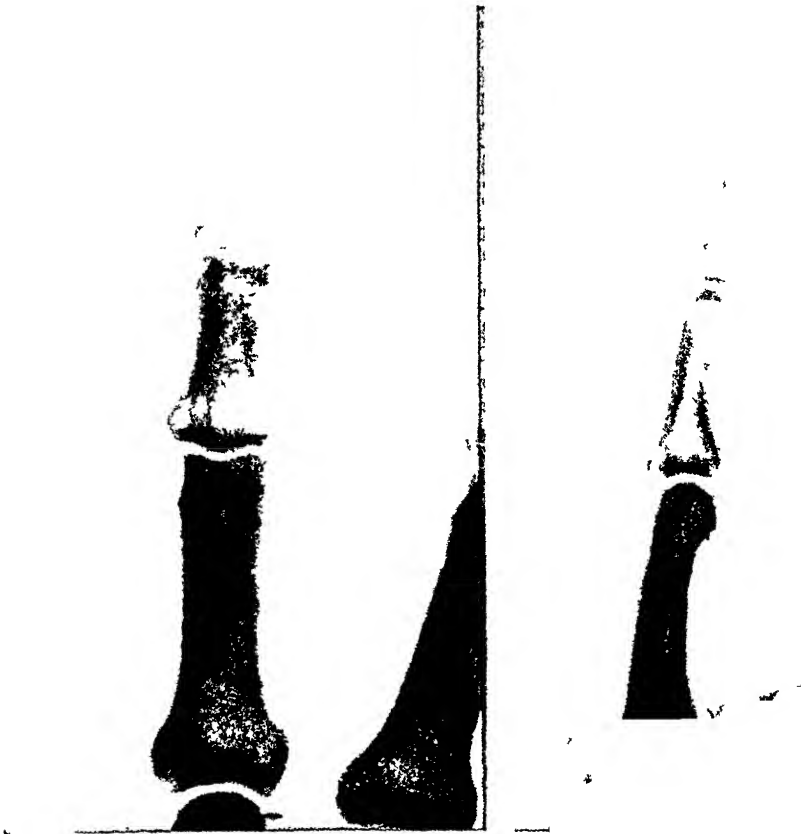


FIG 12

FIGS 9 10, 11 and 12—Case 3 Showing, in sequence (Fig 9) No evidence of bone involvement (Fig 10) Five days later, still no evidences of osteomyelitis (Fig 11) One week later, shows the distal phalanx almost completely destroyed (Fig 12) One week later, shows the phalanx regenerating, the wound healing, and regeneration of a new nail

genogram, taken March 17, 1939 (Fig 10), still failed to reveal any evidences of osteomyelitis. However, one taken March 24, 1939 (Fig 11), shows the distal phalanx almost completely destroyed, while another, taken March 31, 1939 (Fig 12), shows the phalanx regenerating. The distortion of the soft tissues was due to a button-hole abscess, close scrutiny of the film shows wound healing and new nail regenerating.

CONCLUSIONS

The advantages of this incision are

- (1) The bone is brought closer to the surface and less soft tissue has to be cut through in order to enter the anterior closed space.
- (2) Early osteomyelitis of the bone can be detected long before the roentgenogram reveals evidences of destruction.
- (3) Adequate drainage is obtained and the wound heals in a shorter period of time. If a sequestrum forms, it can be more easily extruded through this incision than through any of those previously recommended.
- (4) There is an absence of scarring on finger, as the nail regenerates completely and covers the scar.
- (5) Sensation is unimpaired.

REFERENCES

- ¹ Kanavel: Hand Infections. Lea & Febiger, Philadelphia, 1939.
- ² Mason: Minn Med, 20, 485, August, 1937.
- ³ Koch: Penn Med Jour, 40, 597, May, 1937.

LUXATION OF EXTENSOR TENDONS IN THE HAND

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EXTENSOR TENDONS in the hand may become dislocated following trauma or disease. The resulting condition, although rare, is characteristic. At first glance it resembles, but should not be confused with trigger finger from other causes. The condition of "trigger finger" or "spring finger" is usually described as being due to impediment of the motion of a flexor tendon by narrowing of the tendon sheath or swelling in the course of the tendon. It should be recognized that the same phenomenon, whereby the finger can be flexed voluntarily, but cannot be extended past an apparent obstruction without assistance, may be caused by the lesion which is herewith described.

Legouest,¹ in 1868, described the first case of luxation of an extensor tendon in the hand. After this Paget,² Marsh,³ and Schuimayer⁴ had reported cases before 1900. Recently, Razemon⁵ was able to collect a total of 17 cases due to trauma, in eight of which the reports lacked sufficient detail to offer statistical material. Charcot,⁶ Krukenberg⁷ and Spitzzy⁸ have reported pathologic luxation from arthritis deformans. Levy⁹ suggested the possibility of a congenital tendency and reported a father and daughter who could voluntarily dislocate an extensor tendon. Other authors have speculated upon the mechanism involved.

After Maydl,¹⁰ the cases can be divided into those due to pathologic softening of structures in the vicinity of the metacarpophalangeal joint, and those due to trauma. The traumatic group may be further divided into those in which the dislocation is caused by a direct blow on the metacarpophalangeal joint which tears the extensor tendon loose from its normal bed, and dislocations from indirect violence caused by contraction of the extensor tendon against resistance, or by external force causing flexion of the finger against muscular resistance. From the recorded cases it appears that the luxation always occurs at the metacarpophalangeal joint. The middle finger was involved in 10 cases, the index finger in three cases. The displacement was toward the ulna in all but one case. Five injuries were caused by direct trauma, of which a fighter's blow to the chin of his opponent may be taken as typical. Five cases, including the present one, were caused by a muscular effort against resistance. One case was apparently due to repeated slight muscular effort. The right and left hands were equally involved.

The patients uniformly give a history of an injury which may be trivial or severe. This is immediately followed by interference with the normal

Submitted for publication November 25, 1938

function of the finger and swelling on the dorsum of the hand. The swelling and acute pain disappear within a few days, but the extensor function of the finger remains permanently impaired, and there is apt to be pain and weakness on use of the finger.

Examination of the older cases, with the fingers in full extension, reveals an apparently normal hand. As flexion of the fingers is executed, when the proximal phalanx of the finger approaches flexion of 45° , a distinct jerk is observed as the extensor tendon slips off the head of the metacarpal bone. At the same time, the finger jumps into a position of deviation toward the ulnar aspect of the hand. As flexion is continued, the finger can complete full flexion in ulnar deviation. When extension is attempted, the motion

FIG 1

FIG 2

FIG 3



FIG 1—Showing the apparent normal relations of the extensor tendon of the middle finger, when in full extension.

FIG 2—Showing the extensor tendon of the middle finger beginning to slip to the ulnar side of the third metacarpal, with finger in 45 degree flexion.

FIG 3—Showing ulnar deviation of the middle finger, upon complete flexion, with the extensor tendon slipped entirely to the ulnar side of the third metacarpal.

proceeds normally until the proximal phalanx again reaches the vicinity of a 45° angle, when the motion is locked or impeded. Frequently, it requires assistance from the examiner or the patient's other hand to carry extension past this point, or it may be that by obvious effort, the patient's own extensor muscle may succeed. In any event, there is a visible and palpable jump as the extensor tendon slips back onto the head of the metacarpal bone. The ulnar deviation of the finger disappears and the extension is normally completed. In recent cases, the displacement of the extensor tendon during this procedure may be masked by swelling. It is easily visible and palpable in older cases. In describing the pathology of the condition, all observers have noted the displacement of the tendon. Becker¹¹ recorded an associated tear of the junctura tendinum uniting the extensor tendon to its radial neighbor. Ritschl¹² recorded a case in which the extensor tendon became split, so that the head of the metacarpal projected through the longitudinal tear in button-hole fashion.

LUXATION OF TENDONS OF HAND

Case Report—A male, age 56, applied at the Central Free Dispensary, July 22, 1937, with the history that one week previously, while bearing his weight on the dorsum of his partly closed fingers as he leaned upon a table, he felt a distinct "pop" and experienced immediate pain in the vicinity of the metacarpophalangeal joint of the middle finger. Since then, the middle finger had been stiff, flexion was painful and extension more so. He had noted swelling in the dorsum of the hand.

Physical Examination As flexion was executed, the extensor tendon slipped to the ulnar side of the third metacarpal and pulled the finger into ulnar deviation. Exten-

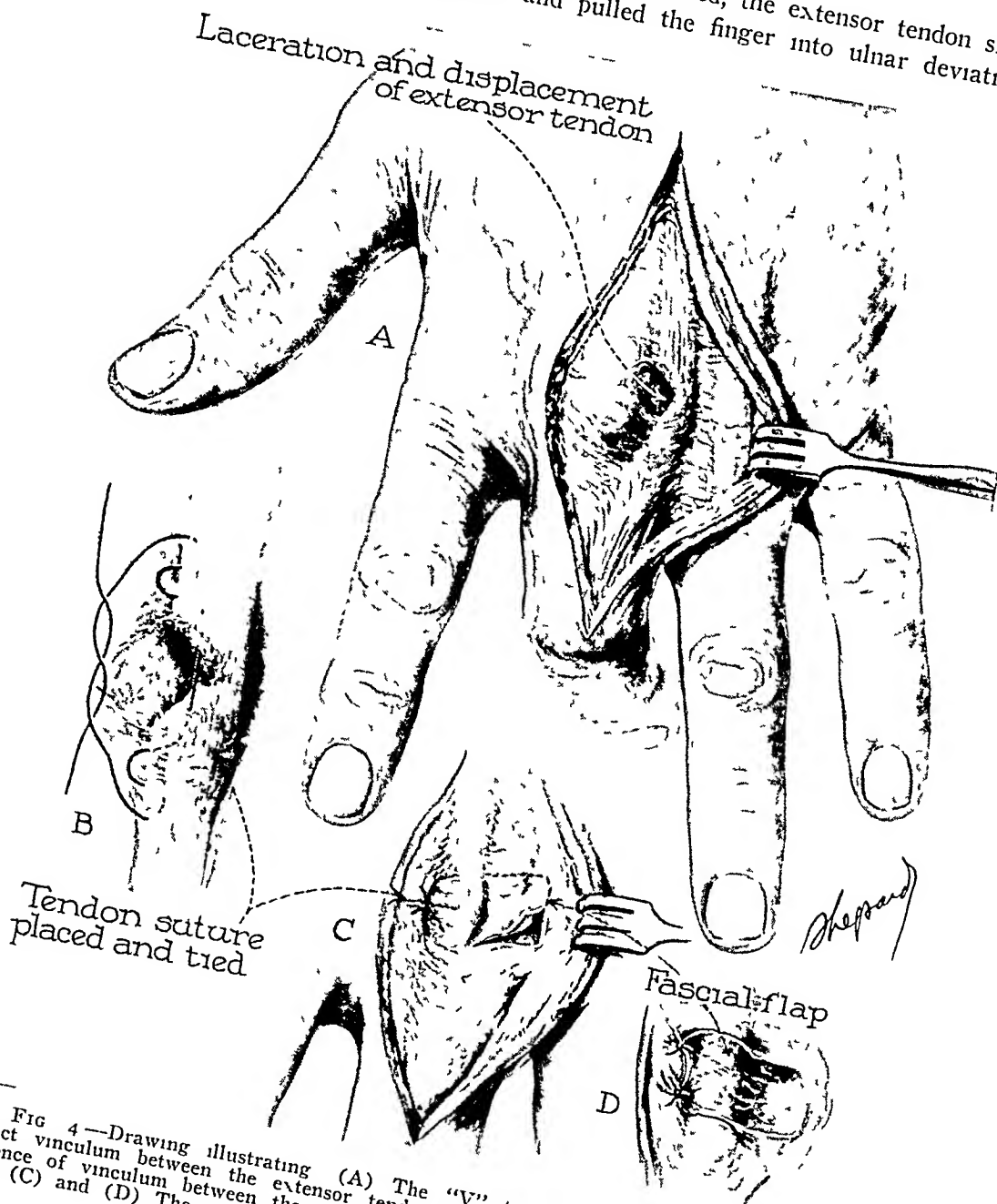


FIG 4—Drawing illustrating (A) The "V" tear in the extensor tendon, an intact vinculum between the extensor tendons of the ring and middle fingers, the absence of vinculum between the extensor tendons of the index and middle fingers (B) (C) and (D) The operative procedures employed in effecting the repair

sion occurred to 45°, and then was so impeded that assistance was necessary to spring the extensor tendon back into its normal position, after which extension was completed normally (Figs 1, 2 and 3). A roentgenogram did not show any bony injury.

Operation—July 2, 1937 Under local anesthesia, a longitudinal incision was made over the metacarpophalangeal joint of the middle finger and the extensor tendon was exposed. At the level of the metacarpophalangeal joint, the medial one-half of the flat

extensor tendon was found to be torn and separated into a "V" (Fig 4A) This allowed the intact lateral one-half of the tendon to slide toward the ulnar side of the metacarpal head It is of interest to note that the dissection was carried widely enough laterally to demonstrate an intact vinculum between the extensor tendons of the ring and middle fingers There was no vinculum between the extensor tendons of the index and middle fingers No gross tear was reported in the capsule of the joint, although there was some granulation tissue in this region which may have obliterated such a tear

The "V" shaped defect in the tendon was repaired by silk suture (Fig 4B) A rectangular flap of connective tissue was turned up from the ulnar side of the tendon (Fig 4C) and sutured over the tendon to the soft tissue on the radial side of the tendon (Fig 4D) The skin was closed over this with interrupted silk sutures and a palmar splint applied Eleven days later, the wound was healed Flexion and extension of the middle finger were normal and there was no luxation of the tendon in any position One year later the condition was unchanged

In considering the mechanism of the injury, we must consider the factors which hold the extensor tendon constantly in its normal position over the narrow projection of the metacarpal head Becker¹¹ believed that this was in part accomplished by the *junctura tendinum* and that laceration of the *junctura tendinum* was a causative factor in dislocation Silfverskiöld¹³ quotes Braus¹⁴ that the *juncturae* are phylogenetic remnants in man of structures which in the apes are broad membranes limiting individual finger motion in the extensor tendons, and which in man are too variable and too obliquely situated to perform any useful stabilizing function Ponier¹⁵ states that fixation of the extensor tendon in its proper site is maintained by transverse bands of fascia which unite the tendon to the posterior capsule of the joint and which in turn unite with the palmar aponeurosis Mason¹⁶ quotes both the preceding theories, and suggests shortening a lax *junctura tendinum* as a possible correction The discussion among the foregoing authors as to whether the laceration of the *junctura tendinum* or of the posterior aspect of the capsule is the etiologic factor, would obviously apply only to those cases in which the injury is due to direct violence The mechanical situation is such that indirect violence will apply little or no force to either the *junctura tendinum* or dorsal capsule if the tendon remains intact

Through the courtesy of Dr Edwin Miller, I investigated this condition on a number of hands of cadavers The extensor tendon of the middle finger fuses indistinguishably with the capsule of the metacarpophalangeal joint This union is so firm that no lateral play is allowed the tendon as it crosses the joint Proximal to the joint, there is considerable lateral mobility of the tendon The lateral mobility here is not affected by the presence of the *juncturae tendinum*, which quite obviously, from their oblique situation, play little rôle in stabilizing the lateral position of the tendon With the scalpel, an incision was made through the radial one-half of the extensor tendon, simulating the lesion found in the case reported The proximal portion of the tendon was fixed in traction, and the tendon made taut by flexing the middle finger This caused an obvious tendency on the part of the tendon to slip over the head of the metacarpal bone toward the groove between the

third and fourth metacarpals. However, this luxation was restrained by the attachment of the tendon to the dorsal ligament of the joint. The tension on the dorsal ligament of the joint could be increased by flexing the middle finger in ulnar deviation.

An incision was made on the radial side of an extensor tendon and parallel to it for a distance of three-quarters of an inch at the level of the metacarpophalangeal joint. The preceding procedure was repeated, whereupon the tendon slipped into a position of luxation between the third and fourth metacarpal bones. It is apparent that there must be rupture or division of the dorsal capsule of the joint before lateral displacement of the tendon is possible. This quite conceivably might occur through disease processes. It probably cannot occur through force supplied by muscular contraction against resistance. However, if the radial one-half of the tendon is ruptured, which may happen through an obvious mechanism (the application of power to the extensor tendon while the finger is fixed in flexion with some ulnar deviation), then the continuing force will be applied to the dorsal capsule of the joint. This in turn gives way, and the tendon slips into the groove to the ulnar side of the metacarpal head. Repeated experiments upon a number of tendons, both with and without vincula, appeared to show that this mechanism was correctly interpreted. Division of the vinculum toward the ulnar side of the extensor tendon and tightening of the vinculum toward the radial side when it was present did not prevent the occurrence of the dislocation.

Various authors (Cuichod,¹⁷ Silfverskiöld,¹⁸ and Mason¹⁶) have recommended that recent cases be treated conservatively by immobilization in extension for three weeks, by which time the torn tissue may repair itself, inasmuch as the tendon occupies its normal position during extension. In the two cases where this has been done (Cuichod and Silfverskiöld), the repair has been sufficient to allow use of the finger, but in both cases there was persistence of partial luxation when the finger was flexed. It would appear that although this method of therapy may be used, it cannot be depended upon for complete restoration, but the functional result may be adequate.

The first operative repair was reported by Haberern,¹⁸ who turned a flap of fibrous tissue over the tendon just proximal to the head of the metacarpal joint to form a retentive sheath in a manner similar to that herewith described. Becker's¹¹ effort to retain the tendon in position by suture of the vinculum resulted in success as far as the luxation of the tendon was concerned, but resulted in limitation of motion.

It would appear that operative repair, in which a retention sling is fashioned from the fibrous tissue just proximal to the metacarpal head, gives good functional and anatomic results. This should be combined with suture of the associated lacerations of tendon and capsule as disclosed by operation.

BIBLIOGRAPHY

- ¹ Legouest, L. Société Impériale de Chirurgie. *Gaz. d. Hop.*, 181, 1868. (Quoted by P. Razemon in reference listed below.)

- ² Paget, J Clinical Lectures and Essays (French Translation) C Balliere, p 150, 1877
- ³ Marsh, H Displacements and Injuries of Muscles and Tendons Brit Med Jour, London, 2, 181, 1896
- ⁴ Schurmayer, B Über einen Fall von Luxation der Strecksehne des Mittelfingers in der Höhe des Metacarpophalangealgelenks Zentralbl f Chir, Leipzig, 24, 846, 1897
- ⁵ Razemon, P Traumatic Dislocation of Extensor Tendon of Second Finger Ann Anat et Pathol, 7, 238, February, 1930, Echo Med du Nord, 34, 213, May 3, 1930
- ⁶ Charcot, J M Neue Vorlesungen über die Krankheiten des Nervensystems, insbesondere über Hysterie Autoris deutsche Ausgabe von S Freud Wien, 1886, Toepflitz and Deuticke
- ⁷ Krukenberg, H Beugecontractur der Finger in Folge von Deviation der Strecksehnen Jahrb d Hamburgischen Staatskrankenanst, 1890, Leipzig, 2, 232
- ⁸ Spitzzy, H Reposition einer Sehnenluxation durch Sehnenbindung Arch f Orthop, 1, 401, 1903
- ⁹ Levy, Wm Über die Sehnenluxation der Fingerstrecker Zentralbl f Chir, 48, 482, 1921
- ¹⁰ Maydl, C Über subkutane Muskel- und Sehnenzerreissungen Deutsch Ztschr f Chir, 17, 308, 1882
- ¹¹ Becker, A Beitrag zur traumatischen nicht komplizierten Luxation der Extensorsehnen der Finger Munchen med Wchnschr, 1, 497, 1903
- ¹² Ritschl, A Über Fingerbeugekontraktur in Folge von traumatischer Strecksehnen-spaltung Munchen med Wchnschr, 54, 1127, 1907
- ¹³ Silfverskiöld, N Luxatio Traumatica Subcutanea Tendin Extens Dig III et Luxatio Habitualis Tend Extens Dig IV man sin Acta Chir Scandinav, 64, 305, November, 1929
- ¹⁴ Braus, H Anatomie des Menschen, 1, 361, 431, 1921
- ¹⁵ Poirier, P Traite d'Anatomie humaine par Poirier et A Charpy Masson et Cie, 2, 1908
- ¹⁶ Mason, M L Rupture of Tendons of Hand, with Study of Extensor Tendon Insertions in Fingers Surg, Gynec, and Obstet, 50, 611, March, 1930
- ¹⁷ Curchod, E Traumatische Sehnenluxation eines Fingerstreckers Bruns Beitrage z klin Chir, 102, 1916
- ¹⁸ Haberern, J Über Sehnenluxationen Deutsch Ztschr f Chir, 62, 191, 1902

A METHOD FOR CONTINUOUS SPINAL ANESTHESIA*

A PRELIMINARY REPORT

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DURING the past 16 years, in an experience with more than 2,000 spinal anesthetics, two difficulties have been observed the first one being "its failure to take"—or failure to produce analgesia, and, the second, "its wearing off too soon"—or pain and muscular contraction returning before the operation is completed, which made it necessary to supplement the spinal with ether, nitrous oxide, cyclopropane, evipal, or local anesthesia

In approximately 200 continuous spinal anesthetics, no instance has occurred in which it "failed to take," A second injection of procaine hydrochloride (novocain, neocaine) was given many times before there was "a take," and on a few occasions it was necessary to give a third injection before analgesia was produced and the operation begun The concentration used was 100 mg of novocain per cubic centimeter of spinal fluid

In every case in this series, the operation has been completed under spinal anesthesia Analgesia has been maintained as long as four hours, requiring several injections of novocain Each subsequent injection has been given as the effects of the previous injection of novocain began to wear off We have observed that it takes less than two minutes (approximately 90 seconds) to obtain complete freedom from pain and muscular relaxation after an intraspinal injection of novocain The initial injection of novocain has more toxic effects than subsequent injections These "toxic effects," of the intraspinal injection of novocain, are evidenced by a fall in blood pressure, sweating, tachycardia, nausea and vomiting These distressing symptoms are prevented or ameliorated, to some extent, by the use of 10 per cent glucose by continuous venoclysis The head of the patient is level or slightly lowered The systolic blood pressure has not dropped below 80 Mm of mercury, and we have not found it necessary to administer adrenalin or ephedrine to support the blood pressure in any instance The continuous venoclysis of 10 per cent glucose supports the patient during the operation and analgesia, and the blood pressure is often the same at the conclusion of the operation as it was at the beginning

Surgeons have experienced the difficulties in closing upper abdominal incisions when it was difficult or impossible to get patients relaxed under general anesthesia They know the ease with which these incisions are closed when the abdominal wall is perfectly relaxed, and the intestines collapsed Indeed, at times the abdominal closure is more difficult than the operation,

* Read before the Philadelphia Academy of Surgery, December 4, 1939

especially when abdominal relaxation cannot be obtained. It will be a comfort to surgeons to find that they can complete their difficult, prolonged operations and close the abdominal incisions under perfect muscular relaxation, and with the intestines collapsed. This I have found to be true in all cases in which continuous spinal anesthesia was used.

The operations in which we have found it to be especially useful are Gastrectomy, colon resections, rectal resections, operations upon the gall bladder and bile ducts, plastic procedures, celiotomies, and pelvic operations. The results were so satisfactory that we felt a preliminary report was justified. Animal experimentation, laboratory investigation, and further clinical observations are being carried out at the present time.

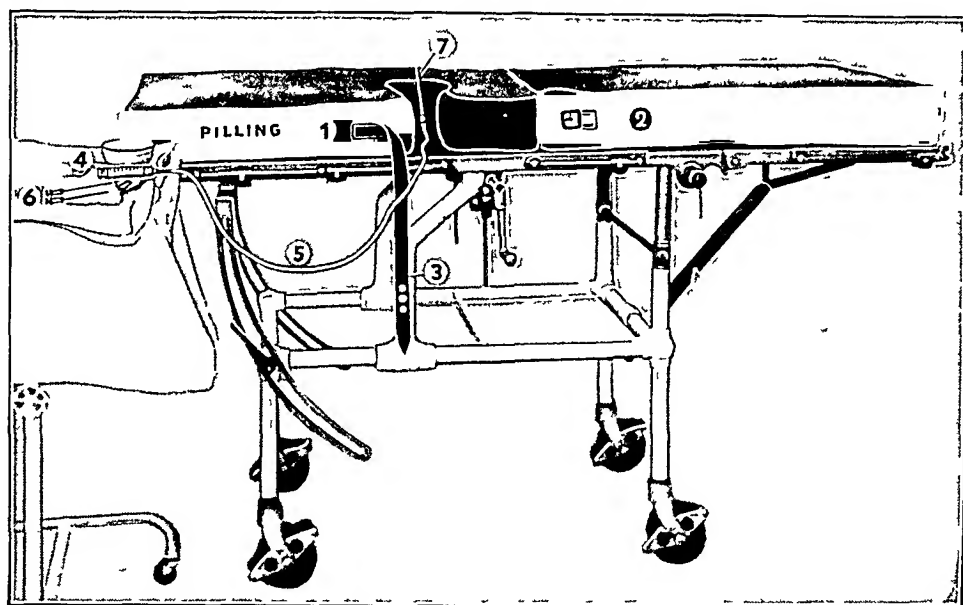


FIG 1—Showing the general set up for the induction of continuous spinal anesthesia

- (1) The mattress upon which the patient's body rests
- (2) The part of the mattress that is detached and removed when the patient is in the lithotomy position for perineal or rectal operations
- (3) The strap that holds the two pads together during abdominal operations
- (4) A basin, filled with sterile water, containing additional ampules of novocain
- (5) A very small caliber of rubber tubing, 36 inches long
- (6) Additional malleable needles of different lengths
- (7) The malleable needle in place in the position that it usually is when it is left in the patient during operation

Equipment—The equipment needed to administer repeated injections into the spinal subarachnoid space, during surgical operations, consists of (1) A rubber covered pad or mattress (2) Spinal needles (3) Rubber tubing (4) Stopcock (5) Luer-lok connections (6) Ten cubic centimeter syringe

(1) The rubber covered (with zipper) mattress is five inches thick, 18 inches broad and six feet long (Fig 1). It has a gap seven inches in length that is beneath the lumbar spine when the patient is supine. This gap is continuous with another gap which comes to the side of the mattress. There is a break in the center of this mattress so that the lower part that supports the lower extremities may be detached. This is detached when the patient has the legs in stirrups for plastic or perineal operations. If an abdominal

celiotomy follows the perineal operation, the patient is pulled back in position on the operating table, and the lower half of the rubber-covered mattress is held in place by straps with buckles. This mattress will fit any operating table. Future operating tables and pads may be made with a space for the use of continuous spinal anesthesia.

The spinal puncture is made with the patient lying on one side, and the back of the patient is toward the side of mattress with the gap in it. As soon as the cerebrospinal fluid escapes, six cubic centimeters are drawn into a 10 cc Luer syringe. The syringe is disconnected, and the needle in the spine plugged with a trocar to prevent escape of spinal fluid. Six hundred milligrams of procaine hydrochloride (novocain, neocaine) is now dissolved in 6 cc of spinal fluid. The 10 cc syringe, containing 600 mg of novocain dissolved in 6 cc of spinal fluid, is now connected to a Luer-lok connection with a stopcock which connects to about three feet of rubber tubing. This stopcock is opened and 2 cc of the fluid containing novocain is forced into the rubber tubing. The stopcock is closed. This fluid displaces the air in the tubing. The Luer-lok connection at the opposite end of the tubing is connected to the needle in the spine. This connection is made secure. The stopcock is opened and 1 to 2 cc of fluid introduced into the subarachnoid space from the 10 cc syringe. The stopcock is closed, and the 10 cc syringe now has the remaining fluid left.

The patient is turned on his back with the needle left in the spine, and the needle is so placed that it is in the center of the gap in the pad. It does not touch the table or the mattress at any time. The patient is then tested for analgesia and relaxation. If analgesia is not present within 10 minutes an additional dose of spinal fluid containing novocain is introduced by turning the stopcock and pressing the plunger of the 10 cc syringe. If additional novocain is needed it may be dissolved in sterile water 100 mg to each cubic centimeter and introduced as it is required. The spinal puncture is usually made in the second or the third lumbar interspace. The level of analgesia has been easily controlled by the position of the patient, dilution of the analgesic drug, and the force of injection. Procaine hydrochloride has been employed because it is the least toxic of all drugs used in producing spinal anesthesia. I see no reason why such drugs as nupecaine, pontocaine and metycaine cannot be used with this method, but they are more toxic. These drugs were developed to prolong analgesia so that long operations could be completed before their action "wore off." It has been found that any of the above-named drugs may "fail to take" and it has also been noted that they often "wear-off" before they are supposed to and before operations can be completed.

Some patients require much more intraspinal procaine to produce analgesia than others. There is no set dose of ether for a given case, but it is given under control as needed and the dose varies greatly. The same is true in operating under spinal anesthesia. The dose should be given as needed and under control.

Spinal anesthesia is the choice for so many operative procedures, and the

results are not as satisfactory when it has to be supplemented by other anesthetic agents

(2) *Needles*—The needles are malleable (made of German silver) and so made that they may be bent in any direction without breaking. The caliber is No. 17- and 18-gauge. They are $2\frac{1}{2}$, 3, and $3\frac{1}{2}$ inches in length, so as to fit fairly accurately the depth of any lumbar spine.

One cubic centimeter of novocain containing $\frac{3}{4}$ grain ephedrine sulphate is withdrawn from an ampule through a hypodermic needle into a 2 cc Luer syringe. This is injected intradermally over the second or third lumbar interspace. An ordinary spinal needle or a needle of No. 17- or 18-gauge in caliber is introduced through the wheal made by the intradermal injection of novocain and ephedrine. The malleable spinal needle is then introduced into the puncture hole in the skin and on into the subarachnoid space. (The malleable spinal needles will sometimes bend before they can be forced through the skin, but a previous puncture by another needle eliminates the difficulty.)

We now use malleable spinal needles in the induction of all spinal anesthesias and all spinal punctures on the Surgical Services. Within one month, two of the ordinary nonmalleable needles were broken off in the spine, due to the patients suddenly bending and moving out of position. These broken needles in the spine are quite difficult, at times, to remove, and constitute a really serious accident, especially when the accident can be prevented by using malleable needles in performing all spinal punctures.

(3) *Rubber Tubing*—The rubber tubing is made of very hard rubber with very little elasticity, so that it will not bulge and allow fluid to accumulate in its lumen. The lumen of the tubing is just as small as could be obtained. With three feet of rubber, it takes 2 cc of the spinal fluid to fill the lumen and force out the air. This 2 cc of fluid and the contained drug remains in the tube and must be subtracted from the total dosage. All tube connections must be air and fluid tight.

(4) *Stopcock*—The stopcock is placed between the Luer-lok connection to the 10 cc syringe, and the connection to the rubber tubing. When it is turned in the long axis of the tubing, it is open. When it is perpendicular to the long axis of the tubing it is closed.

(5) *Luer-lok Connections*—There is one Luer-lok connection that fits the malleable needle placed in the spine. The other Luer-lok connection is placed at the stopcock. It is very important that these be kept tight so that there may be no leakage of air or fluid.

Ten Cubic Centimeter Luer Syringe—A 10 cc Luer-lok syringe, or any 10 cc syringe that fits the connection may be used. Usually 6 cc of spinal fluid are withdrawn and 600 mg of novocain dissolved in it. Two cubic centimeters are used to fill the lumen of the rubber tubing, and, 1 or 2 cc are introduced into the subarachnoid space, to produce analgesia. Two cubic centimeters are left in the syringe to be used as needed.

BRIEF COMMUNICATIONS AND CASE REPORTS

RECONSTRUCTION OF COMMON BILE DUCT*

SEVEN-YEAR RESULT

THOMAS H RUSSELL, M D

NEW YORK, N Y

Case Report—Hosp No 762 J L, white, female, age 42, married, was admitted to St Francis Hospital, and was operated upon by another surgeon, January 30, 1931, at which operation the gallbladder and appendix were removed. The patient was seen in consultation by the writer (T H R) two days later, at which time she was nauseated, the abdomen moderately distended, temperature 101° F, pulse 100, there was a moderate degree of jaundice present, icteric index 55. *Clinical Diagnosis* Occlusion of common bile duct.

The wound was immediately reopened and the common duct easily identified. The first ligature seen was found to encircle the common bile duct, just above the point of junction with the cystic duct, and had already initiated a local gangrenous process. There was also a ligature around the stump of the cystic duct.

Operative Procedure—The ligature around the common duct was removed, a longitudinal incision made in the duct, and a T-tube inserted. A cigarette drain was placed down to the foramen of Winslow, and the wound closed in layers with plain catgut, the skin with silk.

Postoperative Course—The patient made an uneventful recovery. The icteric index was 30 the first day, and 17 on the third day postoperative. Unfortunately, on the twenty-first postoperative day the T-tube slipped out, and bile began draining from the abdominal wound.

The patient insisted upon going home, February 28, 1931, four weeks postoperative. Four days later, March 4, 1931, the patient was readmitted to the hospital, Hosp No 1605, stating that the wound had continued to discharge large quantities of bile, and that she was troubled with a good deal of abdominal distress after meals. Her stools were formed and natural in color. After a few days' rest in the hospital she felt better, but on March 16, 1931, there appeared to be slight jaundice, the icteric index was 11. In a few days the jaundice disappeared and she felt well again. On March 31, 1931, she became decidedly jaundiced, icteric index 40, and stools clay colored.

Second Operative Procedure—The abdomen was reopened, April 4, 1931, by incising through the old scar, and the common duct again examined. A stenosis of about one inch in length was found at the site of the previous choledochostomy opening. The stenosed part of the duct was excised, and an effort made to approximate the two ends of the duct over a T-tube. As about one inch of the duct had had to be removed, accurate apposition of the ends was not feasible, hence, the likelihood of recurrence of the stricture at this site was most probable.

Reports of various operations designed to establish a fistula to later anastomose into the stomach having, heretofore, been unsatisfactory in a large percentage of cases, a different procedure was attempted which consisted of bringing the longer end of the T-tube up along the posterior wall of the stomach just proximal to the pylorus, sewing a piece of the gastrohepatic omentum about the tube so as to fix it to the stomach wall, with the

* Presented before the New York Surgical Society, October 26, 1938. Submitted for publication January 17, 1939.

idea of having a sinus form along the stomach wall which would later open into the stomach. This procedure was accomplished very easily. The abdominal wound was again closed around the tube and a cigarette drain.

Postoperative Course—The cigarette drain was removed on the third postoperative day. Bile drained from the abdomen around the T-tube for several days, then ceased. In a few days the T-tube was pinched off with a Murphy-drip clamp for several hours a day until finally the patient was taught to unpinch the clamp for a few minutes night and morning, and to keep the tube in position by means of adhesive strips.

The patient was discharged from the hospital, May 2, 1931. She returned every few weeks for examination until October 20, 1931, when she was readmitted, Hosp. No. 4195, for the final operation. She had gained in weight and stated that she felt well and had been doing her usual household duties. Icteric index 10.

Third Operative Procedure—October 26, 1931. The sinus around the tube was dissected free, down to where the tube had been fastened to the posterior wall of the stomach. A two-inch incision was then made through the anterior wall of the pyloric end of the stomach parallel to its long axis. A stab wound was then made through the posterior wall of the stomach into the sinus containing the tube. Several inches of the longer end of the tube were cut off and the tube pulled through into the stomach. The tube was cut off flush with the inner surface of the posterior wall of the stomach, but was not removed, as it had been retained with so much difficulty and it was thought it would soon be discharged into the stomach. The anterior wall of the stomach was closed transversely to its long axis to avoid narrowing at this point. The excess sinus was cut off and the end sutured. The abdomen was closed without drainage. The patient made an uneventful recovery. On November 12, 1931, a plain roentgenogram of the abdomen showed the tube to be still in position. The patient left the hospital, November 14, 1931, and returned every few months for roentgenologic examination.

On March 9, 1932, this patient was presented before the New York Surgical Society and advice solicited relative to the advisability of removing the tube.

On August 3, 1932, 15 months postoperative, she again returned, Hosp. No. 3352, complaining of a ventral hernia. The herniation which presented consisted of a weakness along the lower end of the scar, and, although the hernia was not disabling, the opportunity was taken advantage of, while effecting its repair, to remove the tube which the roentgenogram showed to be still between the common duct and the stomach.

Fourth Operative Procedure—August 10, 1932. The old scar was excised under spinocaine anesthesia. The anterior wall of the stomach was opened parallel to its long axis. The tube, which was presenting through the posterior wall of the stomach, was grasped with a hemostat and removed. Bile flowed freely through the new opening. The anterior wall of the stomach was closed transversely to the line of incision as before, the hernia was repaired and the abdomen closed without drainage.

Subsequent Course—The patient has gained markedly in weight, and has remained well since the last operation, over six years ago, except for an arthritis.

DISCUSSION—DR. FRANK B. BERRY (New York) recalled the fact that he had shown a similar case before the New York Surgical Society, two years ago, that was still alive, 11 years after the original injury. Here again, a rubber tube was used. The gap in the duct was not as extensive as that confronting Doctor Russell. The rubber tube passed by itself. He wondered why, with the tube functioning so well, Doctor Russell did not leave it alone, to eventually disintegrate and be automatically discharged. Doctor Berry mentioned another case of injury, to which he was not a party, which had been referred to him to have the fistulous tract implanted into the stomach. This was planned in Doctor Berry's case. The secondary operation, however, proved to be extremely simple, because the duct, with its gradual stenosis over

the area, had formed a markedly dilated area and the anastomosis was a much simpler operation than was the case in Doctor Russell's patient

DR RUSSELL said that he was advised that if he left the tube alone it would cause trouble and that he had seen several cases of Doctor Erdmann's years before, in which the tube had become filled with gummy material. He felt that it would have continued to function in this case but he also felt that while he had a good opportunity to take it out, he might better take advantage of it.

DR J WILLIAM HINTON (New York) recalled that ten years ago it was said that every patient with a duodenal ulcer developed cholecystitis and appendicitis, and so the appendix and gallbladder were taken out. But Doctor Hinton's experience has impressed him that seldom, if ever, does one find any trouble with the gallbladder in such cases, and he himself has never found one really diseased.

DR JOHN A MCCREERY (New York) agreed that cholecystitis and appendicitis were relatively infrequent concomitants of ulcer. They should be, according to the old text-books, but this is not the case in patients as they are seen. Occasionally, however, one will find a gallbladder which is involved as a result of adhesions around an old perforation.

HEMANGIOMA OF LIVER*

SUCCESSFUL RESECTION OF LEFT LOBE

JOHN H MORRIS, M D

NEW YORK, N Y

Case Report—Hosp No J-5872 M C, white, female, age 38, reported to the Out-Patient Department, Post-Graduate Hospital, September 29, 1935, complaining of pain in the scar at the site of an incision made 20 years previously for an acute infection of the right index finger. Roentgenologic examination disclosed evidence of bone erosion. Other than the present finger infection she, apparently, had never been ill before. She had had seven normal pregnancies. Examination of the right index finger showed a small, tender cicatrix near the tip, but there was no evidence of acute inflammation.

During the course of a routine physical examination, which in the main was entirely negative, there was found a large, grapefruit-sized tumor in the midepigastrium which, according to the patient, had been present since childhood and had never given rise to any pain, digestive or other symptoms. The tumor was firm, lobulated, painless and quite freely movable. It did not, however, move with respirations and, while it could be easily displaced upwards into the epigastrium and laterally, attempts to displace it into the lower abdomen were unsuccessful, indicating a point of fixation above. *Proceptive Diagnosis*—This seemed to rest between a cyst or tumor of the pancreas, omentum or mesentery.

Operation—October 7, 1935. Doctor Morris. Upon opening the abdomen through a right pararectus incision, a large, lobulated, beefy, red, glistening tumor was exposed. It was attached above by a broad pedicle to the under surface of the left lobe of the liver. The dome of the right lobe presented a small elevated angiomatous area the size of a half dollar.

* Presented before the New York Surgical Society, November 23, 1938. Submitted for publication January 8, 1939.

Using a diathermy knife, the left lobe of the liver was resected wide of the tumor pedicle, hemorrhage being effectively controlled by interlocking, deep mattress sutures combined with cauterization. Two large cigarette drains were inserted to site of the excision and the abdomen closed.

Subsequent Course—Convalescence was uneventful except for a thick discharge along the drainage tract. On discharge from the hospital, November 6, 1935, there was still present a small fistula which, however, had closed completely when seen one month later.

FIG 1

FIG 2

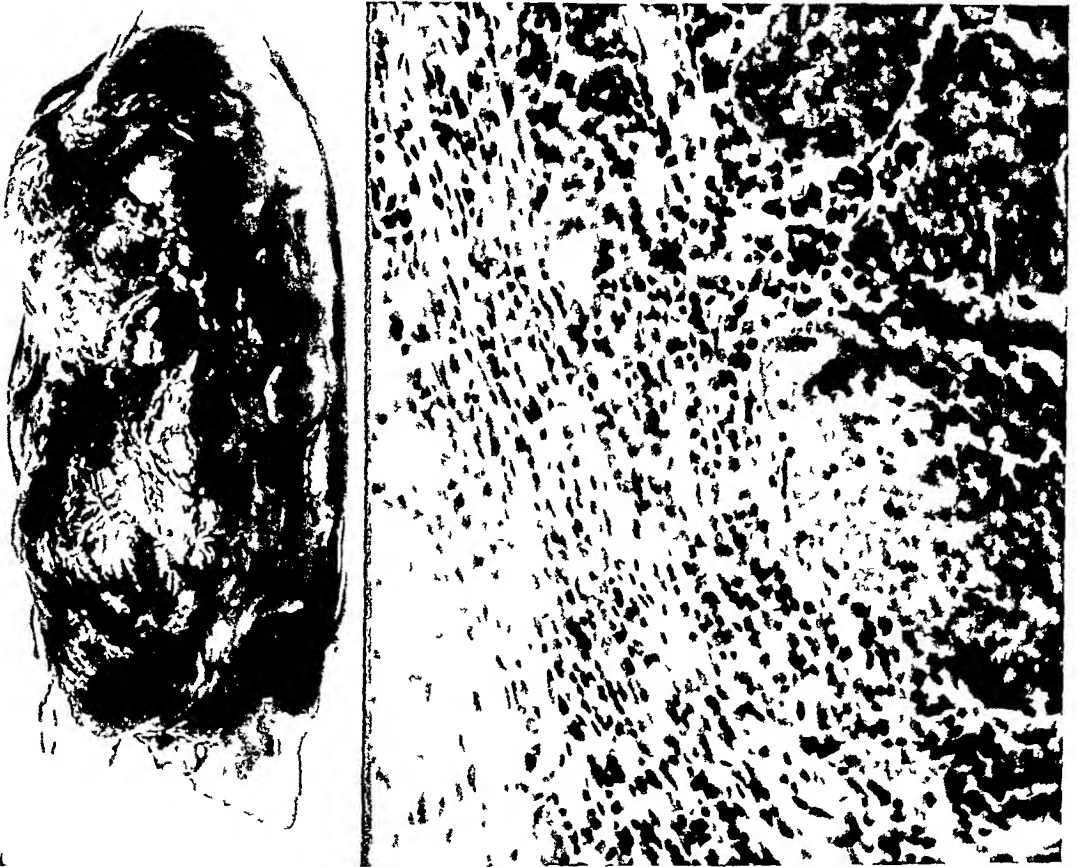


FIG 1—Photograph of the gross specimen of the resected cavernoma of the liver

FIG 2—Photomicrograph showing the histologic structure at the junction of the vascular tumor with the liver

Follow-Up—December 5, 1935. A fist-sized mass was found over the right lobe. It appeared probable that the small angiomatous area noted on the right dome of the liver at the time of operation had taken on active post-operative growth.

Treatment on this mass by roentgenotherapy was begun December 10, 1935, and during the succeeding month, eight treatments of a one-third erythema dose were given. When last seen, September 22, 1938, the wound was firmly healed, no masses were palpable, there was no evidence of recurrence and the patient was symptom free.

Pathologic Examination—*Gross*. Dr S M Rabson. The specimen (Path No 32539-65664) measured 180x160 Mm, and weighed 920 Gm after being sectioned (Fig 1). Its color varied from light gray to black through reddish-blue and purple, its surface in some areas suggested spleen and in others lung. Its cut section showed evidences of extremely vascular tissue. Between widely separated interlacing bands of firm, gray tissue

there was moderately firm tissue, grayish-red in color, formed almost exclusively of pin point to pin-head-sized alveolar spaces

Microscopic—Sections taken through the neoplasm and liver tissue at their junction, show the liver tissue to be normal in appearance. The vascular tumor is well demarcated from the adjacent liver tissue by numerous lamellae of connective tissue which are continuous with the rich stroma between the blood vessels of the tumor (Fig 2). The blood vessels are lined by flattened endothelial cells and in some areas connective tissue cells appear to be directly lining the blood spaces. *Pathologic Diagnosis*—Cavernous hemangioma of the liver (cavernoma)

Ewing⁹ states that these tumors are of congenital origin, on the basis of small nevi, and that they tend to enlarge steadily over a period of many years. When allowed to progress, they attain very large proportions and successively involve neighboring tissues and organs. Some cellular angiomas exhibit certain features of malignancy, and are eventually fatal, chiefly through internal hemorrhage and anemia. Virchow traced the earlier stages of cavernoma to islands of proliferating connective tissue surrounding cellular capillaries, and Ribbert found, on the edges of cavernoma, new vessels which communicated freely with those of the tumor but imperfectly with those of the surrounding tissue. Most authorities agree that these growths are partial neoplasms originating from embryonic disturbances.

In 1921, Dr Charles H. Peck¹ reported a similar case in a female, age 34. The tumor, successfully removed, weighed 3 pounds 14 ounces, and was believed to be the largest tumor to have been removed in the United States and second only to that reported by Pfannenstiel,⁷ which weighed five pounds. Reviewing the literature, he was able to collect 20 cases which had been operated upon, in 17 of whom the tumor was excised, with 15 recoveries and two deaths. The left lobe was most frequently involved (11 cases) with the right lobe second in frequency (7 cases). He records a case (Mantle⁵) in which the patient died from hemorrhage resulting from an accidental needle puncture of the tumor. In another instance (Freund), the patient died from hemorrhage resulting from the rupture of a large hemangioma of the left lobe, which had been exposed during an exploratory celiotomy. Keen⁸ suggests forming an artificial pedicle by incising the liver on either side of the growth, applying an elastic ligature and then packing the wound wide open. Peck cautions against incision or even needle puncture of the tumor itself.

This case is presented because it is an example of a rare type of primary liver tumor whose classification, method of treatment and prognosis are not definitely established. In this instance, radical excision has secured a three-year cure, but it is noteworthy that activity of a small nodule in the right lobe was apparently controlled by roentgenotherapy, confirming the observations of Dr Bronson S. Ray¹ in a case of extensive, inoperable hemangiomas of the liver which has, apparently, also been completely controlled by roentgenotherapy alone.

REFERENCES

- ¹ Ray, Bronson S. Large, Cavernous Hemangiomas of the Liver. *ANNALS OF SURGERY*, 109, 373-382, March, 1939.

- ² Peck, C H Surg, Gynec, and Obstet, 33, 277, 1921
³ McCallum, W G Textbook of Pathology, Phila, 1920, 2nd ed, p 965
⁴ Major and Black Am Jour Med Sci, 469, 156, 1918
⁵ Mantle, A Brit Med Jour, 1, 365, 1903
⁶ Chiari, O Muenchen med Wchenschr, 56, 1615, 1909
⁷ Pfannenstiel Allg med Centr Ztg, 67, 177, 1898
⁸ Keen, W W Penn Med Jour, 1, 193, 1897
⁹ Ewing, J Neoplastic Diseases, 3rd ed, W B Saunders & Co, Phila, 1928

DISCUSSION —DR CHARLES GORDON HEYD (New York) These tumors are relatively rare. They are seldom observed at operation although, not infrequently, they are found at postmortem—according to Adams they were noted 20 times in 1,400 autopsies. It was, furthermore, significant that this tumor had not caused any symptoms and had been discovered during a casual or routine physical examination. Doctor Heyd could not recall having seen any primary tumors of the liver. One thinks of the liver as predominantly the site of fibrotic or biliary changes and not of primary tumors. There are a number of so-called "cavernous" tumors that one sees not infrequently. It was interesting to note that Doctor Morris had called the case one of cavernous hemangioma or cavernoma, which he had thought was associated with age and capillary ectasia, with primary or secondary atrophy of liver cells, whereas hemangiomata are tumors of arterial development, arising from or near the edge of the liver, with the apex fixed within the liver tissue and are, as a rule, capable of resection. Doctor Morris stated that Doctor Ewing was responsible for the term "cavernoma," which appears in his book of neoplasms.

As to the symptoms. From the cases Doctor Morris was able to check from the histologic viewpoint, it is remarkable how little difficulty these patients have had as a result of this tumor. This particular patient had recognized the existence of the tumor but owing to the fact that it never gave her any trouble, pain or other discomfort, she had never given it a second thought. That seems to be true of a great many of the reported hemangiomata of the liver.

STRANGULATED MECKEL'S DIVERTICULUM

ROWLAND W BACHMAN, M D, AND JOHN W NOBLE, M D

ALLENTOWN, PA

IN THE EMBRYONIC LIFE of certain individuals, in which the closure and the obliteration of the vitelline duct before birth are imperfectly effected, a portion, or even the whole, of the intra-embryonic segment of the canal may persist as a pervious tube. Although, in extreme cases of faulty closure a passage may lead from digestive tube to the umbilicus, and later open upon the exterior of the body as a congenital umbilical anus, the retention of the lumen of the vitelline duct is usually much less extensive, being limited to the proximal end of the canal, where it is known as Meckel's diverticulum. The latter is connected with the ileum at a point most frequently about 82 cm (32 inches) from the ileocecal valve. Such diverticula usually measure from

5 to 7.5 cm in length, and possess a lumen similar to that of the intestine with which they communicate

When these conditions are met with in surgery, without an umbilical opening, they are obscure cases to diagnose and can easily be overlooked. The symptoms are most often those of an acute appendicitis or an intestinal obstruction. The pain, colicky in type, is centered more about the umbilicus, more colicky than in an appendiceal involvement and more severe. The tenderness is typically in the region of the umbilicus rather than in the right iliac fossa. As these diverticula so often contain blood within their lumina, blood in the stools may be a valuable clue. The temperature, pulse, respiration, as well as the blood count is not unlike that found in an acute appendicitis. The age of the patient might have some slight significance as the condition generally occurs in children or early adult life.

Case Report—A schoolboy, age 12, was admitted to the Allentown Hospital, with the history of having felt no ill symptoms until he had eaten a light meal at noon, when he experienced pains in his lower abdomen, radiating to the right iliac fossa. These pains continued and became progressively worse. They were the real colicky pains, so much so that while he was being examined he would say "oh, here comes another pain." He did not vomit but felt slightly nauseated.

Physical Examination revealed tenderness over the appendiceal region, with some slight muscle protection over the lower abdomen. Temperature 98° F, pulse 88, respirations 20. The blood picture showed Hb 60%, RBC 3,550,000, WBC 10,700, polys 70%, lymphs 26%, monos 4%. Coagulation time 3 minutes.

Operation—About six hours after the onset of the first symptoms the patient's abdomen was opened through a Deaver incision, under general anesthesia. On opening the abdomen, a clear watery fluid exuded from the incision. This in itself suggested something more serious than just a mild appendicitis. The appendix was found in its normal position, contained several hard concretions and presented a subacute appearance—not acute enough to explain the presence of the clear, watery fluid present.

The appendix was removed, the incision slightly enlarged and the abdomen explored. Nothing unusual was found in the region of the umbilicus, but springing from above the umbilicus, apparently from the ileum, and running longitudinally the length of the abdomen down into the pelvis, was a long cylindrical tube. This was then visualized. Attached to the ileum was a dark red, almost black, Meckel's diverticulum, 15 cm in length. The distal tip was attached to the mesentery, close to the vertebrae in the pelvis, by a fibrous band.

The distal end of the fibrous band was severed, thereby, freeing the diverticulum. The base was then ligated, clamped and the distal portion excised. The base was then sutured with two rows of linen sutures, invaginating the stump. The abdomen was closed without drainage. The patient was discharged on the twelfth day after operation.

Pathologic Examination—*Gross* The specimen was 15 cm in length and 1 cm in diameter at its base, and tapered to a fibrous tip which had been adherent to the mesentery. The strangulation was caused by a twisting of its base. The contents of the diverticulum consisted only of blood.

A résumé of this case would indicate two important points in its diagnosis: (1) The presence of true colicky pains in the midabdomen. (2) An abundance of clear watery fluid in the abdomen following a short, acute history.

REFERENCES

- ¹ Mecray, P M, Ristine, E R, and Gunter, J U Abdominal Emergencies Associated with Meckel's Diverticulum Case Report Jour Med Soc New Jersey, 34, 384-386, June, 1937
- ² Collins, D C Acute Abdomen Caused by Meckel's Diverticulum Canad Med Assn Jour, 37, 564-565, December, 1937
- ³ Wolfson, W L, and Kaufman, B Acute Inflammation Meckel's Diverticulum ANNALS OF SURGERY, 89, 535-540, April, 1929
- ⁴ Obenour, S W Gangrenous Diverticulum Associated with Suppurative Appendicitis Ohio State Med Jour, 34, 175-176, February, 1938
- ⁵ Cabot Case 23391 Gangrene Meckel's Diverticulum New England Med Jour, 217, 559-561, September 30, 1937
- ⁶ Walkling, A A Volvulus of Right Colon and Meckel's Diverticulum Amer Jour Surg, 36, 705-707, June, 1937
- ⁷ Hunter, P M, and Kehr, E F Acute Appendicitis with Acute Meckel's Diverticulitis Calif and Western Med, 44, 199, March 1936
- ⁸ Montgomery, A H Surgical Conditions Associated with Meckel's Diverticulum Internat Clin, 1, 216-225, March, 1935
- ⁹ Pemberton, J de J, and Stalker, L K Meckel's Diverticulum, Review of 20 Cases with Report of 2 Cases (One with Obstruction and Other with Bleeding Ulcer) Surgery, 3, 563-567, April, 1938
- ¹⁰ Miller, P H, and Wallace, R H Meckel's Diverticulum in Acute Abdominal Emergencies ANNALS OF SURGERY, 98, 713-721, October, 1933
- ¹¹ Mixer, C H Meckel's Diverticulum and Its Surgical Significance Proc Inst Med, Chicago, 9, 285-308, April 15, 1933
- ¹² Neiman, A Acute, Strangulated Meckel's Diverticulum by Fibrous Band with Gangrene Case Report Ill Med Jour, 56, 466-467, June, 1931
- ¹³ Doolin, W Acute Abdominal Emergencies Due to Presence of Meckel's Diverticulum Irish Jour Med Sci, p 299-305, July, 1929
- ¹⁴ Hunter, W C Perforated Gangrenous Meckel's Diverticulum in Newborn Infant Case Report Amer Jour Dis Chil, 35, 438-442, March, 1928

ABDOMINOPERINEAL RESECTION OF THE RECTUM FOR LYMPHOGRANULOMA*

CASE REPORT

JOHN H MORRIS, M D

NEW YORK, N Y

Case Report—W P, white, male, age 43, was admitted to the Fourth Surgical Division, Bellevue Hospital, May 5, 1938, complaining of anorexia, distention after meals, and loss of weight dating back to an operation performed two years previously, at another hospital, for stricture of the rectum

Ten years before this date, he had developed rectal symptoms which, he was told, were due to stricture and, during the ensuing eight years, he had been under more or less constant treatment which included five attempts at dilatation of this stricture. The condition, however, became progressively worse and, two years ago, a loop sigmoidostomy was performed. The patient felt much better for the first few months post-

* Presented before the New York Surgical Society, November 23, 1938. Submitted for publication January 5, 1939.

operative but subsequently began to experience difficulty in emptying the bowel through the colostomy stoma, even with the aid of catheter irrigation. During the past nine months he has noted marked distention and distress after meals, and for this reason has been compelled to limit himself to one meal a day. During this period his weight dropped from 134 to 116 pounds.

Veneral History—This records a primary luetic infection 15 years ago, confirmed by positive Wassermann reaction, which after prolonged treatment was pronounced negative. He had had an acute gonorrheal urethritis 11 years ago.



FIG 1—Photograph of gross specimen showing the thickened rectal walls and the occluded lumen.

Physical Examination—The patient appeared undernourished and pallid. Temperature, pulse and respirations were normal. Wassermann negative. Red blood cells 4,400,000, hemoglobin 65 per cent. Urinalysis negative. The abdomen presented, in its left lower quadrant, a loop colostomy which had been sectioned, leaving a proximal and distal stoma, both of which were almost closed by cicatricial contraction about their orifices. In addition, a muscular defect about the proximal stoma permitted a prolapse of this whole area, which, taken together with the strictured orifice, produced, intermittently, an actual obstruction of the proximal loop.

Rectal examination revealed a complete, annular stricture of the rectum two inches above the anal orifice, the mucosa up to this point appeared grossly intact. There was no general or local lymphadenopathy.

The intradermal skin test with the Frei antigen was repeatedly positive, and this result was further confirmed when graded intravenous doses of Frei antigen gave positive results in terms of typical temperature reactions. *Diagnosis*—Lymphogranuloma inguinale, with anorectal syndrome.

Operation for removal of rectal pathology by means of abdominoperineal resection was decided upon, this step being justified by the consideration that, since lymphogranuloma inguinale is known to be a progressive lymphatic-borne disease which invades and

destroys contiguous tissues, the indication for removal of all active foci is clear. The strictures about the colostomy stomata were interpreted as an extension of the granulomatous process previously noted via rectal lymphatics into sigmoid loop. Furthermore, the status of the sectioned colostomy precluded the possibility of reestablishing continuity of the intestine, so that the distal sigmoid loop and rectum served merely to harbor a dangerous progressive infective focus.

Operation—May 5, 1938 (Dr John H Morris). A plastic, extraperitoneal resection of the distal three inches of the strictured proximal stoma was performed. The hernia in this region was then repaired and new stoma established. After recovery from this procedure the patient was discharged to the O P D, but was again admitted for final operation, August 3, 1938. At this time the distal sigmoid stoma was freed, the sigmoid and rectum mobilized from above, and the operation completed by perineal removal. The postoperative course was uncomplicated. The abdominal wound healed per primam and the perineal wound closed by granulation within six weeks.

Pathologic Examination—Gross Path No 3474-38, Doctor Johannsen. Perianal skin shows no new growth or sinus opening and anal mucosa is well preserved. On sectioning the tumor, it is seen that the rectum describes a tortuous course through the mass. Wall of rectum 1.5 to 2 cm thick and traversed by radial bands of yellow, fibrous connective tissue. Lumen patent, but occluded by pressure from without. Mucous membrane necrotic. *Microscopic*—Complete destruction of normal architecture. Few areas show muscle fibers. Section, in main, is made up of dense connective tissue in which cellular reaction is scant. There are, near the lumen, a few areas of lymphocytes fairly well walled-off. *Pathologic Diagnosis*—Chronic productive inflammation.

Present Status—Patient still complains of some distention after eating, and general weakness of the abdominal muscles. Bowels moving normally through stoma. Weight, however, still subnormal.

COMMENTS—This case is presented as an example of a rather severe degree of lymphogranuloma inguinale in which surgical therapy seemed to be the sole indication. The significance of the evidence pointing to the extension of the disease process to involve the sigmoid loop is apparent and definitely places this condition in the surgical field, unless some more effective conservative method is devised.

DISCUSSION—DR W HOWARD BARBER (New York) thought that Doctor MORRIS had very well described a typical case of lymphogranuloma as it is seen at Bellevue Hospital. The cases, when they come to surgery, are chronic, almost hopeless, badly depleted physically, obstructed, suffering from pain and tenesmus, and having considerable bloody and purulent discharge from the rectum. Apparently, the infection spreads not only through the lymphatics but also through the portal blood, and not only by continuity but through the wall of the colon, giving rise to quite extensive ulcerative colitis in some cases. The paramount surgical indication is drainage and the best means to obtain drainage is by resection. Doctor Barber cited personal records of 26 cases operated upon—one plastic operation, two colostomies, and 23 resections, five of which were sacroperineal, and 18 abdominosacroperineal. Of the resections, four were lost, three being very advanced cases with extensive colitis extending well into the descending colon. From the follow-up on these cases it appears that they increase in weight, feel very much improved, and learn to control the artificial anus. On the whole, one feels quite encouraged to continue this line of attack in instances of lymphogranuloma during the advanced chronic stage with rectal symptoms.

DR HENRY F GRAHAM (Brooklyn, N Y) felt that the important factor, in cases of lymphogranuloma, is to avoid extensive operation by early diagnosis, and described a case on his service thought to be a very early one of lymphogranuloma. The patient, a young man, came in with marked rectal tenesmus and sphincteric spasm. Proctoscopy revealed a very red anal canal with the lower two or three inches of the rectum involved and showing plaques of fibrin on the surface. The Frei skin test was positive. The patient was given the Elliott treatment with the rectal bag about 10 times and then was transferred for intravenous antigen treatment. At the time of his discharge from the hospital there was marked improvement in his local condition. A similar case was seen in St. Mary's Hospital some time ago. While there was some tendency to stricture formation, it was found that the best results were obtained with diathermy through a rectal applicator. It would be interesting to try to make an earlier diagnosis, followed by heat treatment in addition to antigens.

DR FRANK B BERRY (New York) said that about five years ago he read a paper on this subject before the Surgical Section. He had followed about 25 cases over a period of 10 years. The disease is certainly not always progressive, but has a tendency to stay localized without progressing further up the colon. Some of the cases he described were permanently relieved by simple colostomy.

DR JOHN H MORRIS, in closing, said that the important factor, of course, is whether or not operation is justified. Many of these cases can be cleared up by conservative methods but in the case reported it seemed utterly futile to waste time, especially in a patient in whom there was quite definite evidence of the progression of the condition into the sigmoid loop. Roentgenotherapy, antigens, *etc*, would have had little or no effect on this type of pathology and would hardly have been worth instituting.

CARCINOMA OF THE PAROTID GLAND IN A YOUTH

CASE REPORT

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TUMORS of the parotid gland comprise a group of infrequent and interesting neoplasms. The occurrence of a carcinoma of the parotid in a child, age 11, it was thought, was of sufficient rarity to warrant reporting. The only reference to its appearance at so early an age was by Jambon,⁹ in 1904, who reported a case of epithelioma in the anterior prolongation of the parotid gland in a child, age six. However, in his report the author was unable to state with surety whether the tumor originated from the parotid gland or whether it was an ectodermic cancer which developed secondarily in the parotid gland. The malignant nature of the case herein reported was unsuspected until the pathologic examination was made.

Submitted for publication January 10, 1939

Case Report—Hosp No 40286 C L, white, female, age 11, was admitted to St Vincent's Hospital, August 21, 1938, with the complaint that she had two swellings, one on the right side of her face and the other on the right side of her neck. Whereas the latter had been present on the side of her neck since she was a baby, the former had



FIG 1—The tumor is composed of large polyhedral cells closely massed together into broad columns (H and E stain, low power)

become noticeable only about one year ago. This tumor had become slowly but progressively larger during the latter part of the year. Neither of the growths was painful or interfered with mastication. She was observed for six weeks prior to admission to the hospital, during which period there did not appear to be any appreciable change in the size of the growths.



FIG 2—A duct within the tumor from the fundus of which a centripetal growth of cells is taking place (H and E stains, low power)

Physical Examination revealed a well developed and well nourished child. Her general physical condition was essentially negative.

Local Condition—TUMOR OF THE RIGHT PAROTID GLAND. A round tumor mass,

measuring 2.5 cm in diameter, was intimately attached to the superior portion of the right parotid gland. Externally, it was situated just anterior and somewhat inferior to the tragus of the right ear. The mass appeared to be superficial, was not tender and felt rather firm and smooth on palpation. It could be moved from side to side and in a downward direction but not upward without causing pain. The mass did not appear to be attached to the surrounding tissue except at its most inferior portion. The overlying skin was freely movable and did not appear inflamed. The facial nerve did not appear to be involved.

TUMOR OF THE NECK The mass in the neck was located just anterior and inferior to the angle of the right mandible and appeared to be attached to the inferior portion of the right submaxillary gland. It was almond-shaped, measuring about 2 cm in length and 1.5 cm in width. The growth was situated rather deeply, felt firm, smooth, and was not adherent at any point. There was no pulsation in either of the tumors.

Laboratory Data—The blood constituents were normal and the blood Kahn was negative. Urine Negative. Temperature and pulse normal. Roentgenologic examination of the right parotid gland region, May 17, 1938, revealed numerous dense shadows, of varying sizes and shapes. **Roentgenologic Diagnosis** Calcification of tissues in the region of the right parotid gland.

Operative Pathology—The inferior margin of the growth in the parotid region was found to be intimately adherent to the superior portion of the parotid gland. The mass in the region of the submaxillary gland was somewhat more deeply situated, and was adherent to the underlying muscles.

Operative Procedure—An incision was made over the tumor in the parotid, the skin dissected away and the mass exposed. It was dissected away from the surrounding tissue and removed. During the procedure branches of the facial nerve were exposed and retracted. They appeared to lie along the upper border of the mass. The submaxillary mass was excised without difficulty.

Pathologic Examination—*Gross* Dr. Antonio Rottino, Path No. 18174. The specimen consists of three irregular masses, measuring 2.2 x 2.2 cm, 1.5 x 1.25 x 1.4 cm and 3.1 x 1.1 cm, respectively. The first two consist of dense, chalky, calcified amorphous material, surrounded by a small amount of loose areolar tissue. The third is solid, firm and composed of homogeneous gray tissue subdivided into small lobules by fine, barely visible, septa.

Microscopic The latter mass is found to be composed of two portions, normal parotid gland and tumor. Between the two is a thin, dense, hyalinized fibrous septum. The tumor is composed principally of broad irregular sheets of large polyhedral cells having distinct cell outlines and clear cytoplasm (Fig. 1). Where the cells are not so closely applied, small intercellular bridges are visible between them. The cell type is uniform throughout. Mitotic figures are not seen. In several portions of the tumor, ducts are found which are identical in appearance to those in the normal portion of the gland. From the fundus of one of these there is a centripetal piling up of cells similar in appearance to those growing elsewhere in sheets (Fig. 2). Tumor growth was found in the lymph channels. **Pathologic Diagnosis** Primary epidermoid carcinoma of the parotid gland.

Postoperative Course—Following operation a hematoma developed at the site of excision, causing facial paralysis. Nothing was done about the hematoma because it was felt it would undoubtedly resolve spontaneously without complications. The child's temperature came down to normal on the fourth postoperative day, and she was discharged on the tenth postoperative day, with both wounds well healed.

Subsequent Course—One month following operation the child began to receive roentgenotherapy at the Memorial Hospital, New York. The progress of her condition appeared to be satisfactory, four months after operation. The facial paralysis had practically completely cleared up and there did not appear to be any recurrence of the tumor.

DISCUSSION —The clinical diagnosis of parotid tumor is usually easy, but to differentiate benign from malignant growth is rather difficult and often impossible. The most common growths of the salivary glands are mixed tumors, 90 per cent of which are located in the parotid gland according to Neil. These tumors may occur at any age, one having been reported in an infant seven months old. The period of greatest incidence is between the ages of 30 and 60.

In reviewing the literature, primary carcinoma of the parotid gland appears to be an extremely rare condition. Ewing² does not believe that pure malignant epithelial tumors of the salivary glands are rare and maintains that the carcinomata usually develop rapidly and while at first they may be encapsulated, they soon invade the gland, the capsule and regional nodes. However, over a period of 24 years, at the Bernard Free Skin and Cancer Hospital (St. Louis), 65,000 patients were seen and 70 presented themselves with parotid tumors. Fifty per cent of these were malignant. The age of patients with malignant parotid tumors varied from 31 to 84. In the group treated surgically, at the above clinic, microscopic sections showed 14 malignant mixed tumors and three squamous cell carcinomata. A moderate number of investigators agree that there is a certain percentage of the simple mixed tumors which definitely undergo malignant degeneration (25 per cent). Stein and Geschickter¹⁰ made a study of 241 cases of parotid tumors and found only 20 per cent of them to be malignant. They found that the malignant lesions usually occurred in persons over the age of 45, and that they have a fairly rapid rate of growth, with an average duration of four years. On microscopic examination, the tissues revealed adenocystic basal cell features. They maintain that the growths with the basal cell features are more prone to recur after treatment.

PROGNOSIS —The consensus of opinion is that in carcinoma of the parotid gland the prognosis is very bad. Very few patients have been cured and extensive radical excision with radiation seems to be the only hope. Swinton and Warren¹ recently reported four cases of epidermoid carcinoma, with one death after one and one-half years and two others with no recurrence after two years and the fourth with no recurrence after four years.

The tumor reported in this case was encapsulated and calcified in its upper portion but apparently infiltrating in the lower part. The infiltrating portion, which has been described in the pathologic report, was an epidermoid carcinoma, not very malignant, and one which does not tend to metastasize rapidly. It is hoped that its early excision, followed by radiation, may afford the patient a cure. The prognosis is, however, reserved.

CONCLUSIONS

(1) A case of primary carcinoma of the parotid gland is herewith reported in a child, age 11.

(2) The early excision of the tumor and intensive radiation may effect a cure, however, the prognosis is reserved

(3) This case emphasizes the importance of careful pathologic examination of a specimen and possibly the importance of the early removal of any parotid tumor regardless of how innocent it might appear clinically

REFERENCES

- ¹ Swinton and Warren Salivary Gland Tumors Surg Gynec and Obstet, 67, 4, 1938
- ² Ewing, J Neoplastic Diseases, p 725 W B Saunders Co
- ³ Martin, T M Treatment of Tumors of Parotid Gland Arch Surg, 36, 136, 1938
- ⁴ Neil, W, Jr Observations in 71 Tumors of the Parotid Gland Med Jour and Rec, 136, 187, 1932
- ⁵ McFarland, J Tumors of the Parotid Gland Studies of 135 Cases Surg, Gynec and Obstet, 57, 104, 1933
- ⁶ Benedict, E B, and Meigs, J V Tumors of the Parotid Gland Surg, Gynec and Obstet, 51, 626, 1930
- ⁷ Merrit, E A Mixed Tumors of the Parotid Gland Amer Jour Roentgenol, 25, 507, 1931
- ⁸ Jackson, A S Mixed Tumors of the Parotid Gland Wisconsin Med Jour, 31, 696, 1932
- ⁹ Jambon Epithelioma in Parotid Gland in Child Age Six Lyon Med, 102, 257, 1904
- ¹⁰ Stein, I, and Geschickter, C Tumors of the Parotid Arch Surg, 28, 492, 1934
- ¹¹ Lewis, D Practice of Surgery Vol 4, W F Prior & Co, Hagerstown, Md

A COAGULATING SUCKER FOR USE IN NEUROSURGERY

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For the last two years we have had in active use an instrument which we find sufficiently helpful to warrant description It is a combination of suction



FIG 1—The combined metal sucker and electrocautery attachment as used The wire and tubing held together by rubber bands

and electrocoagulation (Fig 1) The sucker is the metal instrument (Frazier) made by Pilling, a set screw placed near its proximal end provides for the optional attachment of a U-shaped electrode connected with the unit used

Submitted for publication January 12, 1939

for electrocoagulation, in our case the Buick instrument (Fig 2) During use the suction tubing and the wire leading to the coagulating units are held together by two rubber bands. It can thus be as easily handled as the unmodified sucker. Electric current is sent through the metal sucker by pressure on a foot pedal.

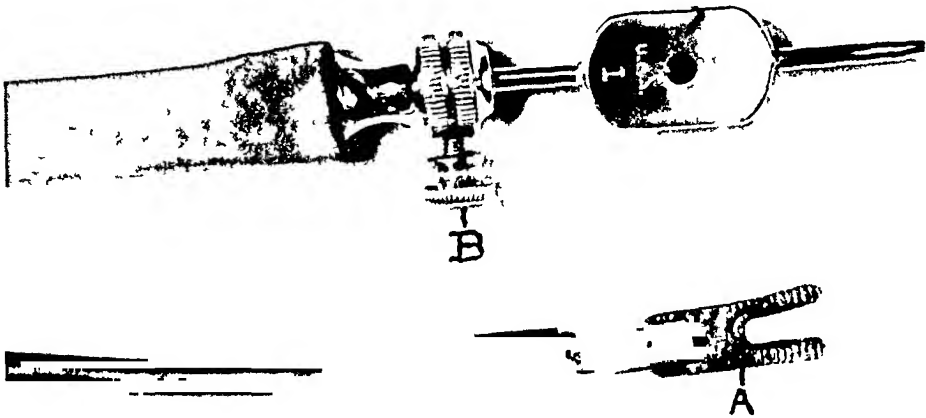


FIG 2—Detail of attachment (A) U shaped electrode on wire to be attached at set screw (B) on sucker

The instrument seems particularly helpful in procedures where rapid coagulation in a moderately moist field is desirable. The fact that suction is applied at the moment of coagulation insures maximum efficiency and minimal spread of electrical trauma. Operative technic on the scalp (bone flap) or back muscles and fascia (laminectomy) is much facilitated by its use.

The device was made with the technical assistance of the Hillel and Heuser Company of Boston.

ERRATA

In the article by Drs Roy D McClure, F W Hartman, J G Schnedorf and Victor Schelling "Anoxia A Source of Possible Complications in Surgical Anesthesia" ANNALS OF SURGERY, 110, 835-850, November, 1939, on page 835, line 2, the last word should read "necrosis" instead of "narcosis", and on page 846, line 3 from the bottom, the seventh word should read "for" instead of "from"

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Walter Estell Lee, M D
1833 Pine Street, Philadelphia, Pa

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ANNALS OF SURGERY
227 South Sixth Street, Philadelphia, Pa



CONSIDERATIONS IN THE USE OF ULTRAVIOLET RADIATION IN OPERATING ROOMS

CORNELIUS J KRAISSL, M D, J GRIER CIMIOTTI, B S,
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FROM THE BACTERIOLOGICAL RESEARCH LABORATORY OF THE COLLEGE OF PHYSICIANS AND SURGEONS, COLUMBIA UNIVERSITY, AND THE DEPARTMENT OF SURGERY OF THE PRESBYTERIAN HOSPITAL, NEW YORK, N Y

DURING the past decade increasing interest has led to many studies of the various factors which affect wound healing in an effort to reduce the complications which may threaten the patient's life or may prolong the stay in the hospital

The factor to which greatest attention has been directed is infection, and every effort has been made to determine the various sources of wound contamination That every wound is contaminated is accepted by nearly every surgeon By improvements in technic in obliterating dead spaces, minimizing tissue trauma, and preventing hematoma, the contaminating organisms will not find suitable cultural environment, but the length of time required to execute a meticulous technic prolongs the time of exposure of the wound to the various sources of contamination Among the most important of these are the skin of the patient, the materials and instruments coming in contact with the tissues either directly or indirectly, and the operating personnel who may harbor organisms on their hands, clothing, shoes, and noses and throats These organisms may fall on the floor, contaminate sterile materials, or be disseminated in the air to fall later on the sterile field

Twenty-five years ago, Brewer⁸ was among the first to conscientiously determine the frequency of operative wound infection He laid particular stress on scrubbing the hands and advised wearing rubber gloves In 1926, Meleney³⁶ emphasized the importance of adequate masking when he identified a hemolytic streptococcus found in a hernia repair wound with a similar organism found in the nose and throat of one of the nurses on the operating team The necessity for masking both nose and mouth has been emphasized by Davis,¹⁷ Walker,⁵⁵ and Waters⁵⁷ Dandy¹⁶ and, more recently, Walter⁵⁶ have stressed the importance of the effectiveness of the sterilizing apparatus, autoclaves, instrument sterilizers, *etc* Tinker,⁵³ Scott,⁴⁹ and others⁴² have reported upon their experiences with agents advocated for skin "sterilization" A number of authors have demonstrated the possibility of wound contamination from improperly sterilized suture materials, especially catgut^{11, 37} In

1935, Meleney³⁸ reported a nine-year study of operating room technic indicating the importance of closing all of the doors through which contamination may come and showing the advantages of silk over catgut in rendering the wound a less fertile soil for the growth of contaminating organisms, a thesis first held by Kocher³⁰ and later by Halsted.²² The philosophy of the "silk technic" has been described by Whipple,⁶² in 1933. Complete clinical and experimental evidence was given to show the superiority of silk over catgut in clean wounds, providing that the precautions of its use were observed. Its value was further emphasized in the repair of abdominal wounds⁶³ where the proper method of employment was given.

In the earliest days of antiseptic surgery, Lister¹² considered the air as a probable source of infection, and carbolic spray was used to kill organisms in the air. It was soon evident, however, that other sources of contamination were equally important and attention was directed toward them. Air as a source of contamination was neglected and Chaplin,¹⁰ in 1914, wrote that a great deal of the theory of air-borne infection was unsupported.

Recently, more serious consideration has been given to the air as an important source of wound contamination. Meleney³⁸ found that ten times as many colonies developed on plates exposed during an operation as on plates exposed in the same operating room while no operation was being performed. He estimated that between 30,000 and 60,000 viable organisms fell upon the "sterile" field during the course of an hour's operation.

The relationship of wound infection and the patient's postoperative course to the bacteriologic content of the air in operating rooms was shown by Drets and Diago.¹⁸ They found that when the operating team came into the room, the normal air contamination was raised 32 times.

Interest in combating air contamination was stimulated by Wells,⁷⁸ in 1934, when he showed that moisture droplets from the nasopharynx do not necessarily fall to the ground, but remain suspended in the air and may be considered responsible for transmission of respiratory disease. The size and viability of the organisms are the important factors. He⁷⁹ studied the effect of ultraviolet radiation on certain species of bacteria in the air and found that they could be destroyed. Further studies were made on the viability of air-borne organisms and their relation to communicable diseases which might arise in schools, hospitals, and other public buildings.

The application of ultraviolet radiation for sterilization of air in the operating room was described by Hart,²³ in 1936. He found that the usual precautions of sterile technic did not control infections in wounds of major proportions such as thoracoplastic procedures unless bactericidal ultraviolet generators were employed. He emphasized the employment of ultraviolet radiation, from a source essentially monochromatic, which would have the highest bactericidal and the least erythematous effect. He used a cluster of eight tubes at a distance of five feet from the operating room table. The bactericidal effect was determined on seeded plates and it was found that the intensity was sufficient to kill the organisms in less than one minute at 54 inches. It was further stated that this intensity would cause only a transitory erythema on a blonde subject after 80 minutes' exposure. In an experimental animal

study, adhesions in exposed viscera were said not to be increased over those of the controls. Hait has reiterated the safety of these doses in his most recent publication²⁴

The patient's course of hospitalization in Hait's reports was extremely satisfactory and showed a material reduction in postoperative temperature, and a tremendous reduction in the incidence of wound infection. Most of his cases were thoracoplasties but later other operations were reported²⁴ to have been performed without hazard.

On the other hand, in attempting to estimate the efficiency of radiation from a different type of generator to sterilize the air in infants' wards, Major and Wilde³³ found no appreciable difference in bacterial colony counts between a ward radiated with ultraviolet and a control ward. No mention was made of the quality or intensity of radiation.

The lay press as well as most of the medical publications¹⁹ have described the use of ultraviolet radiation as being very efficient and any hazards connected with its use have been either neglected or minimized. It is the purpose of this paper to report our observations during four years of study and to caution surgeons who contemplate its use to determine that the radiation has the most effective bactericidal quality, that the intensity of the radiation is sufficient to materially reduce the bacterial content of the air and, not so great, over a given period of time, to do tissue damage.

Physical Considerations—Without entering too deeply into a discussion of physics, it may be well for us to consider briefly the fundamental nature of ultraviolet radiation³¹. It will be at once apparent that the term ultraviolet "light" is a misnomer as light is only that part of radiant energy which renders objects visible. The relationship of ultraviolet radiation to visible and infra-red rays may be best appreciated by the diagram,⁴⁸ shown in Figure 1, the numerals of which are approximate values.

Ultraviolet	Visible	Infra-Red
136 Å to 3,900 Å	3,901 Å to 7,700 Å	7,701 Å to 4,000,000 Å
(An Ångstrom unit is 1/10,000,000 millimeter)		

FIG. 1—Showing the relationship of ultraviolet radiation to visible and infra red rays

To determine the "quality" or wavelength of radiation from any given source, it is necessary to examine it with a spectrograph. This consists basically of a quartz prism and an appropriately ruled scale. A photographic plate is exposed and gives the lines of emanation from the generator.

Radiant energy generators⁵⁰ are of three main types. Temperature radiators such as (1) the sun and filament lamps, which give a continuous spectrum, (2) arc lamps which radiate a mixed spectrum, and (3) vapor discharge lamps which radiate a discontinuous line spectrum (Fig. 2). Because there is more heat than ultraviolet radiation associated with the first two types of generators, it is not logical to consider them as a source for the rays with which we are now chiefly concerned. The third type, namely, vapor, and particularly mercury vapor discharge lamps, are the only ones giving a

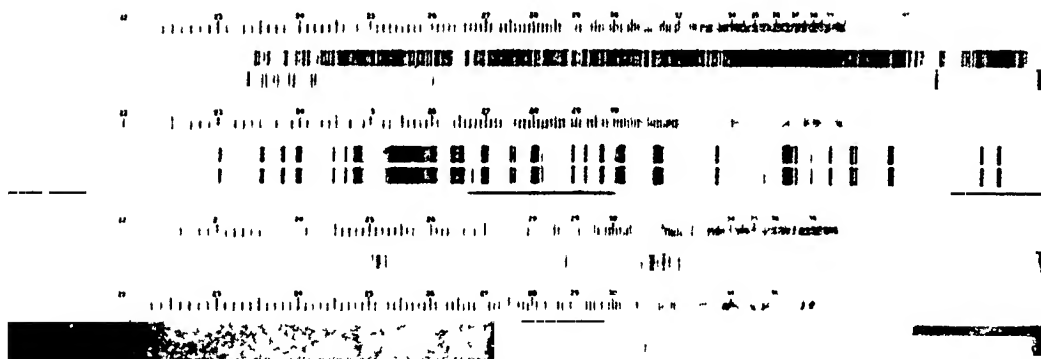


FIG 2—Spectrograph showing type of radiation from different types of generators (Laurens³¹)
The first pair of spectrograms are of the iron arc (6 A, 35 V), exposures of 20 and 60 seconds, respectively. The second pair are of the mercury arc in quartz (5 A 70 V), exposures of two and five seconds respectively. The next single spectrogram is of the flaming carbon arc (28 A 60 V) exposure of five seconds. The bottom spectrogram is of the sun taken on May 24, 1928, at 11 A M. exposure of 15 seconds.

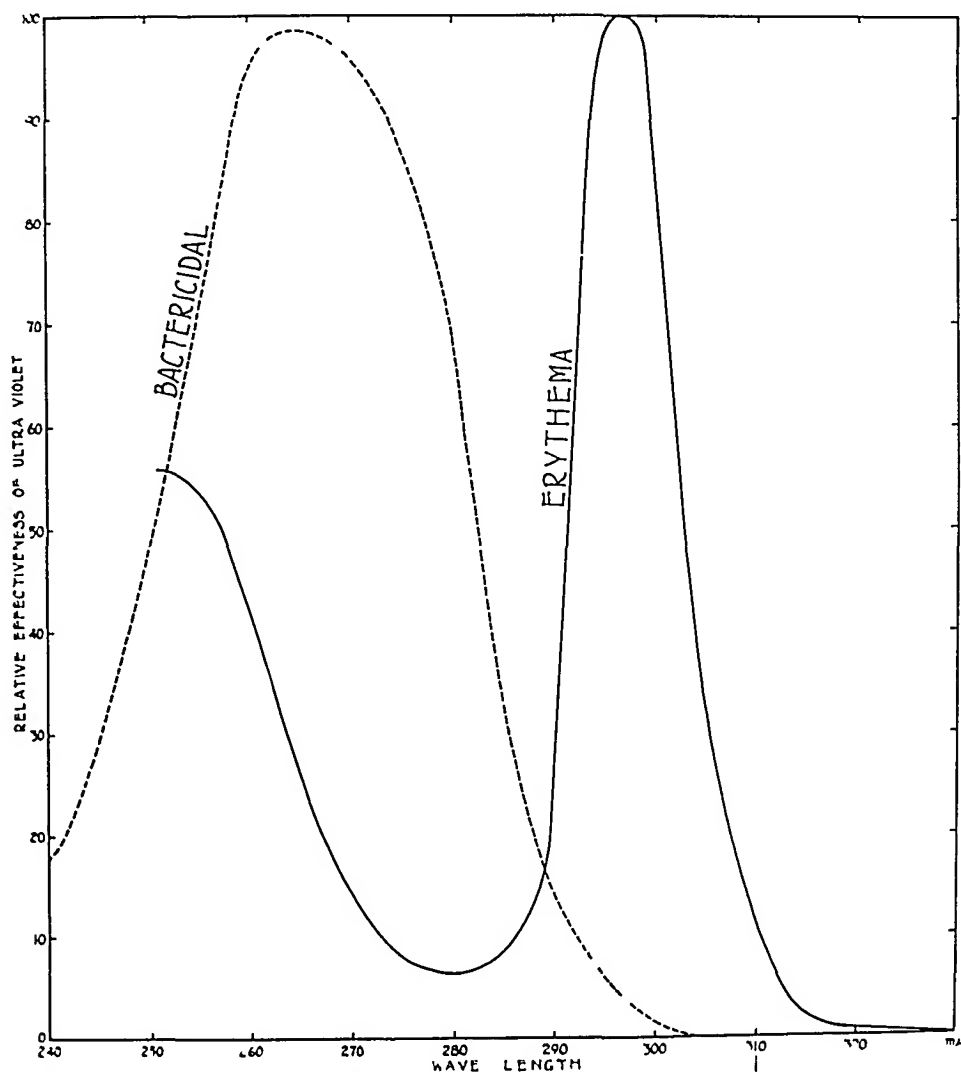


FIG 3—Curve showing relationship of bactericidal effect (Ehrismann and Noethling²⁰) to the erythema effect (Coblentz *et al*¹⁵)

large part of their radiation in the ultraviolet spectrum. However, as will be seen subsequently, not all mercury vapor discharge lamps give off the same type of radiation in this spectrum. The "quality" or length of waves emanating from such a source depends on the nature of the gas or gases and the filtration of the container in which the discharge takes place.

The physiologic effect of any wavelength of radiation is extremely critical. This is best brought out by considering the different colors in the visible part of the spectrum. From one end of the colored spectrum to the other, the violet rays differ from the red by about 35/100,000 of a millimeter. The rays yielding blue light differ in wavelength from the rays yielding green light by only 5/100,000 of a millimeter.²⁷ So that, when we consider radiations in the zone of shorter wavelengths, it might be expected that rays varying only slightly in length might produce quite varied physiologic results.

That there have been differences in the effectiveness of different wavelengths of the ultraviolet spectrum was appreciated at a relatively early date. Barnard and Morgan,² in 1903, stated that the most effective bactericidal range lay between 3,287 Å and 2,265 Å. Henri²⁶ also found that the action was greater as the wavelength decreased but that the short rays were less able to penetrate protoplasm. Newcomer³⁹ narrowed the zone of optimum bactericidal action to the region between 3,000 Å and 2,150 Å. In 1918, Bovie⁷ demonstrated that paramecia were best killed at 2,800 Å. Further bactericidal work on various organisms by many observers was summarized in Coblentz's¹³ work, in 1935, in which the most effective range was found to be in the shorter wavelengths and rapidly diminished at 3,650 Å. The curve of Ehrismann and Noethling²⁰ has its peak at 2,537 Å and diminishes to nearly zero at 3,000 Å. Coblentz¹⁵ also studied the erythema production of various wavelengths on the untanned human skin and his curve is shown on the accompanying chart comparing it with the bactericidal effect of Ehrismann and Noethling (Fig. 3).

Many theories have been advanced regarding the photochemical effect of ultraviolet on bacteria. It was at first thought that certain wavelengths were specific for different bacteria. This assumption was not confirmed by Bayne-Jones and Van der Lingen.⁴ Bedford⁵ believed that the effect was obtained through the production of hydrogen peroxide within the organism. Burge⁹ believed the action to be due to a coagulation of the protein rather than any action on intracellular enzymes and he demonstrated its effect on immature paramecia rather than on the more mature forms. Rentschler⁴⁵ confirmed this with respect to *Bacillus coli*, and by properly timing the cycle was able to materially reduce the amount of radiation necessary. He suggested that the effect is probably dependent on the square area exposed, as adult bacteria about to divide are almost twice as large as the young forms.

The effect of ultraviolet radiation on multicellular organisms has been appreciated for many years. Bernhard,⁶ in 1902, reported the use of sunlight on wounds and was very enthusiastic in a report of its healing property in the treatment of a long-standing suppurative wound. Later, he used artificial ultraviolet for this purpose. Rollier⁴⁷ used sunlight alone very successfully in

treating patients with traumatic injuries as well as tuberculous patients Rasero,⁴³ in 1922, advocated the use of an artificial quartz burner with progressive intensity in treating wounds and ulcers Toriaca,⁵⁴ from 1921 to 1924, experimenting with guinea-pigs, found that wounds exposed to sunlight healed better than others

Before any consistent results can be obtained with a physical agent, one must know how much of this agent is being used Inasmuch as ultraviolet radiation extends over a spectral band, it is necessary to have a method of determining how much radiation is being given off in each of the dominant bands

A history of the various methods of measurement has been compiled by Laurens³¹ At the present time there are two main methods (1) Those based on biologic or photochemical reactions which measure a gross intensity, and (2) those which employ accurate physical methods such as described by Coblentz¹⁴ He used a complicated apparatus consisting of a photo-electric cell, a balanced amplifier, and a micro-ammeter which will measure minute intensities in the various spectral bands of the sun's radiation

A simpler form of radiometer has been developed by Rentschler⁴⁶ and accepted by the American Medical Association⁶¹ This has been designed to measure intensities of ultraviolet radiations from artificial sources By altering the type of glass filter from which the bulb is made and having a metal which is sensitive to a particular wavelength range, the radiometer is given a selective range and will measure the quantity of radiation in that range Three cells are available the thorium, measuring the range from 3,200 to 3,700 Å, the titanium, measuring the range from 2,700 to 3,200 Å, and the tungsten, below 2,700 Å (Fig 5) The intensity is read directly in "clicks per minute" which is an empiric value for each instrument[†]

Physicists^{12 20} and manufacturers of ultraviolet generators^{1 44} were consulted and proved to be of great help in obtaining experimental equipment

Our preliminary experiments were performed with a mercury vapor quartz tube, such as is in general use by physiotherapists This was discarded because of its lack of mechanical adaptability The next type of tube was more adaptable and had similar output characteristics but was of greater intensity However, it was found to cover too wide a range of the ultraviolet spectrum including the ozone producing range The third type attempted to correct the faults of the second by putting an outer jacket over the quartz tube, the space between containing dilute acetic acid This jacket and fluid filtered out the shorter ozone producing rays and a large proportion of the higher wavelengths

At this stage of our early experimental studies, a fourth ultraviolet generator was made available which was developed by James,²⁰ in 1930, and applied by Rentschler⁴⁴ It has been described by Sharp⁵¹ as a low pressure mercury vapor discharge through a glass tube permitting a "high transmission" in a narrow zone and is said to give an essentially monochromatic output

[†] Proper calibration for an instrument is available at the Bureau of Standards, Washington, D C

in the wavelength 2,537 Å, having 88 per cent in this field, the remainder lying above 2,000 Å. A spectrograph of this is shown in Figure 4 and may be compared to those shown in Figure 2. The experimental generators were compared qualitatively and quantitatively by means of three different radiometers and the results show that the maximum intensity of radiation was given

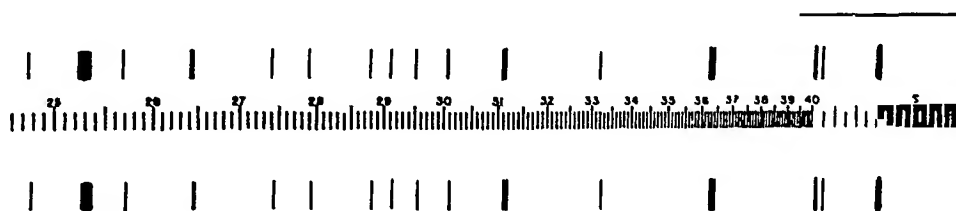


FIG 4—Spectrograph, with the monochromatic generator (Sharp⁵¹), of the lamp output at 27 Ma of current

off in the zone 2,000 to 2,700 Å from all three generators. The monochromatic generator and the jacketed quartz tube practically limit their rays to this zone, but the quartz burner, without the jacket, permits a considerable portion of rays in the zone 3,200 to 3,700 Å to come through and also emits the shorter ozone producing rays. This may be seen in Figure 5.

	<i>Tungsten Tube</i>	<i>Titanium Tube</i>	<i>Thorium Tube</i>
Range	2,000-2,700 Å	2,700-3,200 Å	3,200-3,700 Å
Distance	100 cm	50 cm	25 cm
Monochromatic generator	8.8 c/m *	0.5 c/m	0 c/m
Quartz burner with jacket	10.5 c/m	1.0 c/m	0 c/m
Quartz burner without jacket	13.0 c/m	1.0 c/m	9 c/m

* c /m = clicks per minute

FIG 5—Showing the relative time of penetration using different tubes between the monochromatic generator and the quartz burner both with and without a jacket

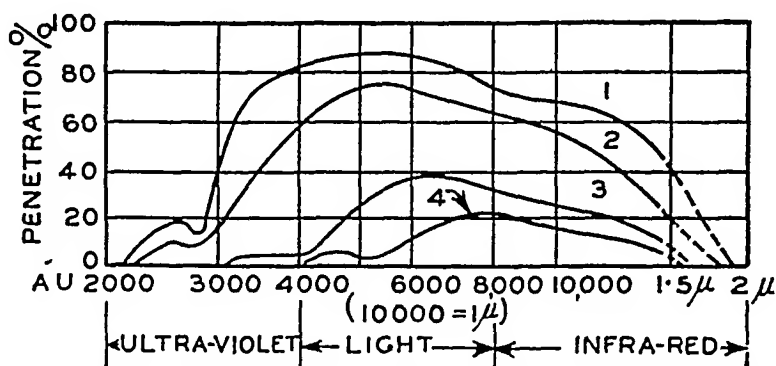
It is apparent that the jacket reduced the erythema rays emitted by the quartz tube, although it still passed twice as much as the same intensity of the monochromatic generator. Also, the jacketed quartz tubes are much smaller than the monochromatic generators and make up for their size by an increased intensity.

Determination of Tissue Injury—Without considering the general biologic effect on metabolism, circulation, and blood, the local effect is of considerable interest. Photochemical changes in tissue are dependent upon the absorption of the rays by those tissues. The various waves in the ultraviolet spectrum penetrate below the skin for variable depths (Fig 6).

The two measurable chemical changes following the radiation of skin are the production of tyrosine, which forms the pigment in the skin, and the change of histadine to histamine,²⁸ which may be developed in sufficient quantity to produce local or general effects. When we expose visceral tissue to this radiation, the problem is somewhat different. While there is no tyrosine reaction, which probably occurs only in the skin, the histadine-histamine changes do occur and may be sufficient to cause a more profound local or

general effect. Moreover, in the skin, certain rays are filtered out, while in the visceral tissues this filtration does not occur to the same extent. It is, therefore, more important to expose visceral tissue to only those rays which are relatively harmless and for periods of time which can be tolerated.

It was thought that we might standardize the dosage of radiation by determining the quantity which produced adhesions in a loop of guinea-pig intestine. The animals were operated upon under nembutal anesthesia and aseptic precautions were observed. The abdomen was shaved and prepared with iodine, which was removed with alcohol. After proper draping, an incision was made and a loop of small intestine, approximately 8 cm in length, was exposed to the radiations, during which time it was kept moist with saline solution. After exposure, the incisions were closed with three silk sutures through the whole wall and a dressing of collodion applied.



Spectral transmission for different skin layers (Bachem)

1 Corneum	0.03mm thick
2 Epidermis	0.05 " "
3 Epidermis and papillary	0.50 " "
4 Epidermis and corium	2.0 " "

The thicknesses stated correspond approximately to nature.

FIG 6—Penetration of skin (Seitz⁵⁰)

The animals which survived were sacrificed after one week and the viscera examined.

As has been indicated before, our first studies were made with a rather intense quartz burner giving a high output over a wide range of the ultra-violet spectrum, as is indicated in Figure 2. Figure 7 shows a loop of guinea-pig intestine, completely gangrenous, exposed for 15 minutes at 18 inches to this generator. The jacketed tube was then used in a similar manner. This caused slight adhesions in a 15-minute exposure at 36 inches, as well as at 18 inches (Fig 8), and is still considered a harmful effect. Further studies on adhesion production were made with the jacketed quartz tube and it was found that they were consistently produced in 15 minutes at 18, 36 and 45 inches.

Similar studies were then made with the monochromatic generator. The criterion of adhesion formation was the agglutination of loops of the exposed intestine (Fig 9). Detailed microscopic studies were made of the effect of this radiation upon guinea-pig intestine. Figure 10 shows a cross-section of

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FIG 7—Showing gangrene of loop of guinea pig intestine radiated with high intensity quartz burner for 15 minutes at 18 inches

36 inches, 15 min



18 inches, 15 min



FIG 8—Lower controls showing no adhesions. Upper specimens are exposed intestines showing adhesions produced by quartz burner with jacket

normal guinea-pig intestine. The serosa is smooth and thin, and the relative size of the vessels may be seen in one area. The effect in a guinea-pig sacrificed two hours after radiation at an intensity of 33 clicks per minute for 15 minutes, is seen in Figure 11. This section shows a red and white cell extravasation just beneath the delicate serosal layer with slightly enlarged vessels and edema developing in the walls. Employing the same dosage, an animal, sacrificed 24 hours after radiation (Fig. 12), shows the edema and blebs to be more evident as well as the tremendous dilatation of the vessels surrounded by an edematous mesentery. A more advanced reaction is to be seen after three days (Fig. 13), in which there is also evidence of degeneration of the glandular elements. At the end of a week, a section (Fig. 14) taken

through an area of adhesion shows extensive glandular destruction. A higher magnification of Figure 14 shows that the fibinous adhesions are beginning to organize although evidences of inflammatory reaction still persist (Fig. 15).

Because of these reactions, it was felt that it was important to determine just how much radiation the viscera could tolerate of different intensities for varying periods of exposure. The results of this study are recorded in Figure 16. The numerator of the fractions in-



FIG. 9.—Showing adhesions produced by the monochromatic generator—54 inches, 33 clicks per minute for 15 minutes.

indicates the incidence of adhesion formation and the denominator the total number of animals exposed at the particular intensity and period of time indicated. From this information a curve of safety was drawn below which it was felt that exposure would not produce adhesions. It will be noted that after one hour, five out of 11 control animals developed adhesions although the intestines were kept moist with saline solution during the entire time. Therefore, this was taken as the longest time to expose viscera safely to air without radiation.

Determination of Bactericidal Action—Having determined the safe zone of exposure in terms of intensity and time, it was necessary to plot the previously determined bactericidal effect at these same intensities and times. This was done using *Streptococcus haemolyticus*, *Bacillus coli*, *Staphylococcus aureus*, *Streptococcus viridans*, and *Bacillus subtilis*. The method was as follows. A blood agar plate was sprayed with a 24-hour culture of organisms diluted 1:100, the Petri dish was covered with cardboard except for a small square opening in the center, and the exposures were made for the indicated intensity and time. One determination, on *Staphylococcus aureus*, is shown in Figure 17. The end-point for this particular determination is six minutes.

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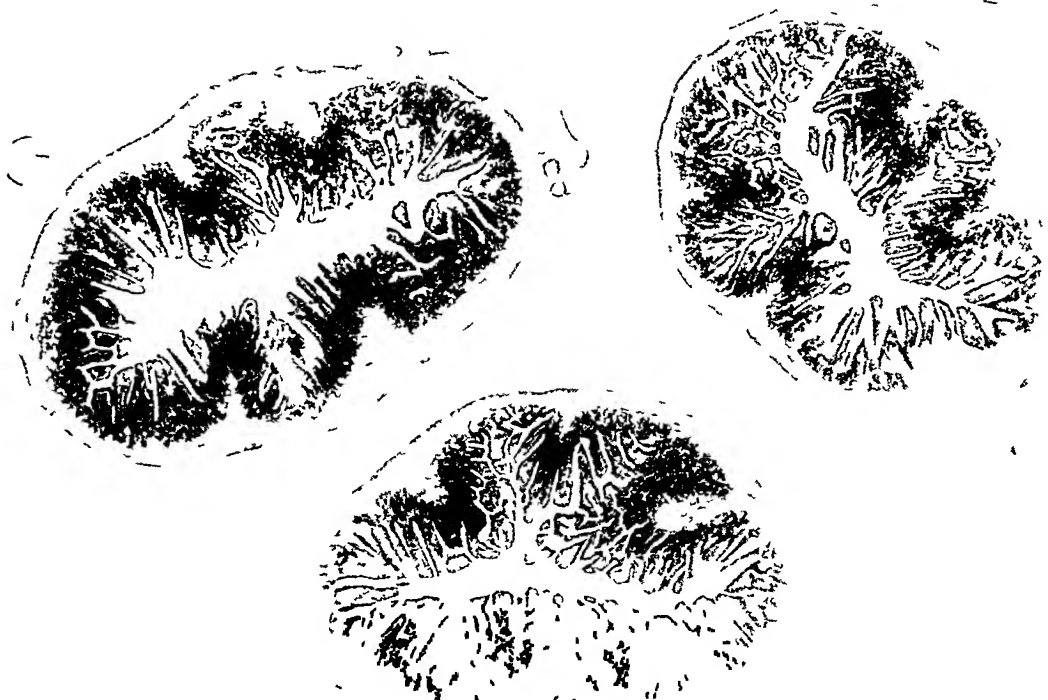


FIG 10—Cross section of normal guinea pig intestine

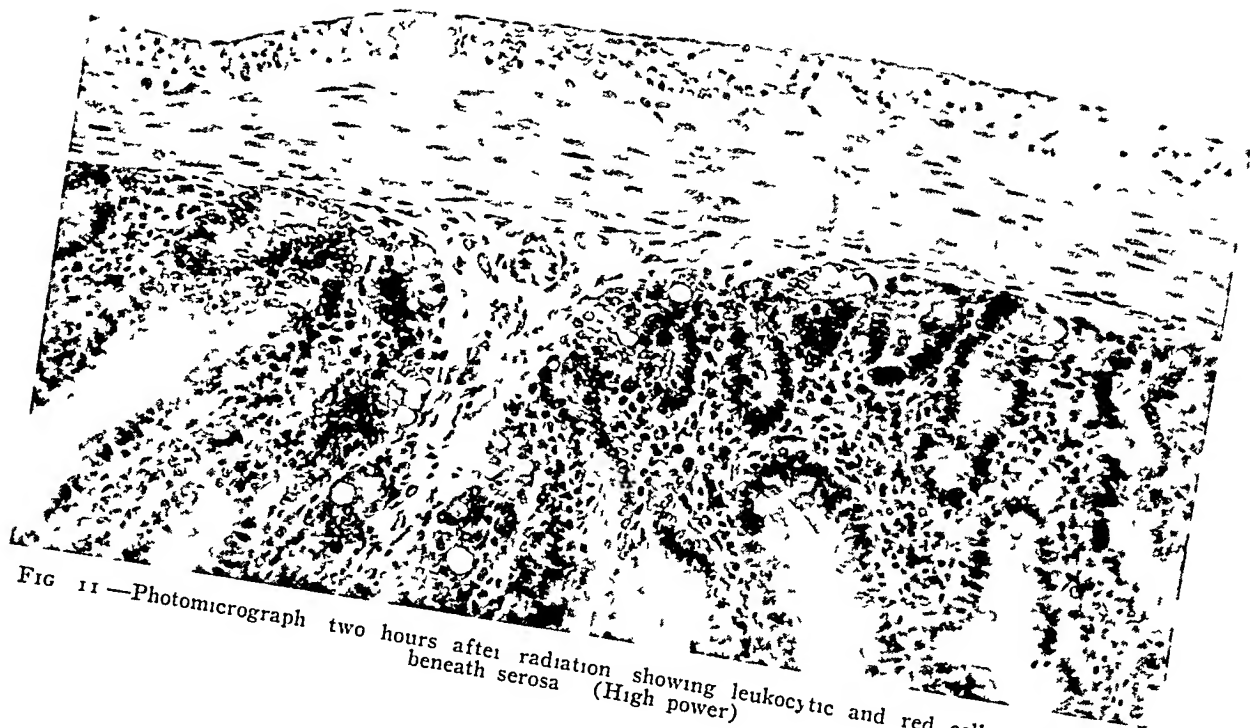


FIG 11—Photomicrograph two hours after radiation showing leukocytic and red cell extravasation beneath serosa (High power)

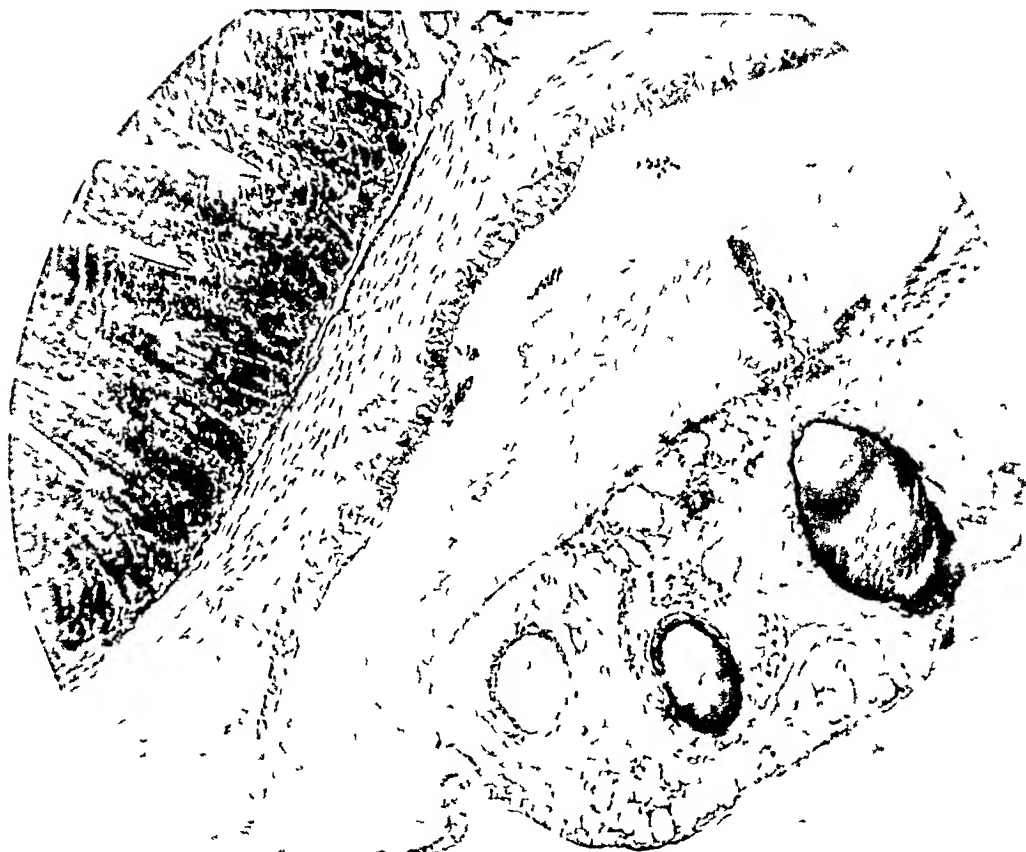


FIG 12—Photomicrograph one day after radiation, showing the development of subserosal blebs and greater hyperemia

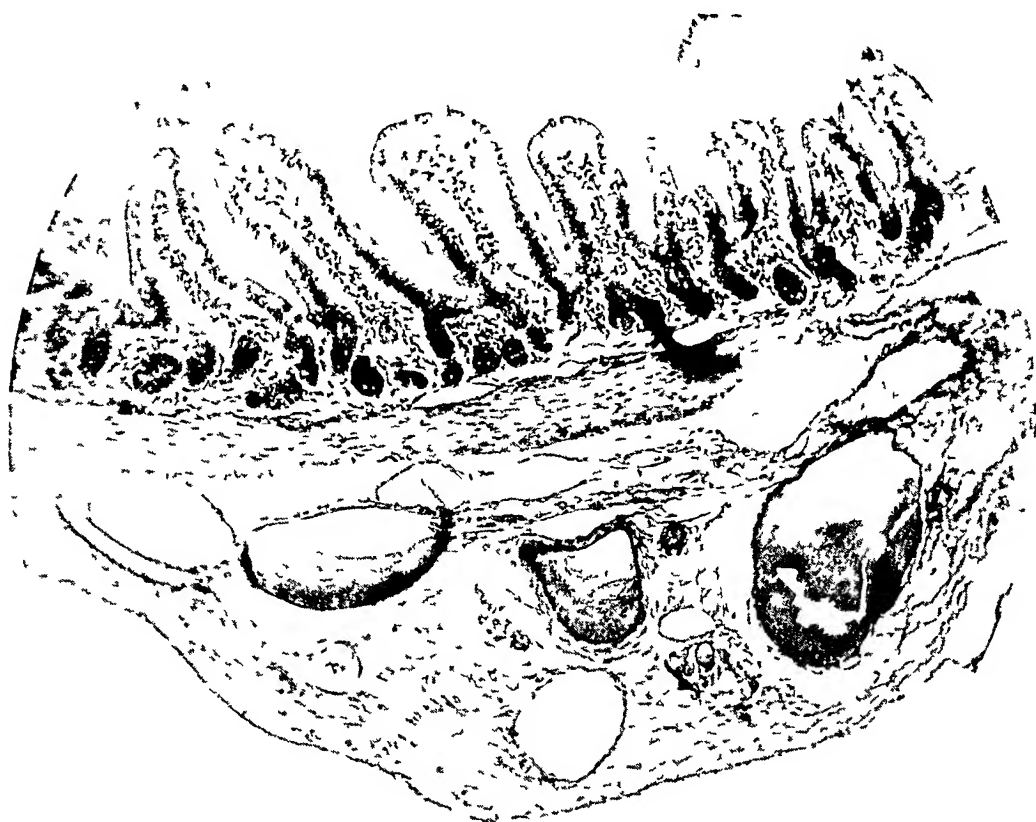


FIG 13—Photomicrograph, three days after radiation showing a beginning degeneration of glandular elements

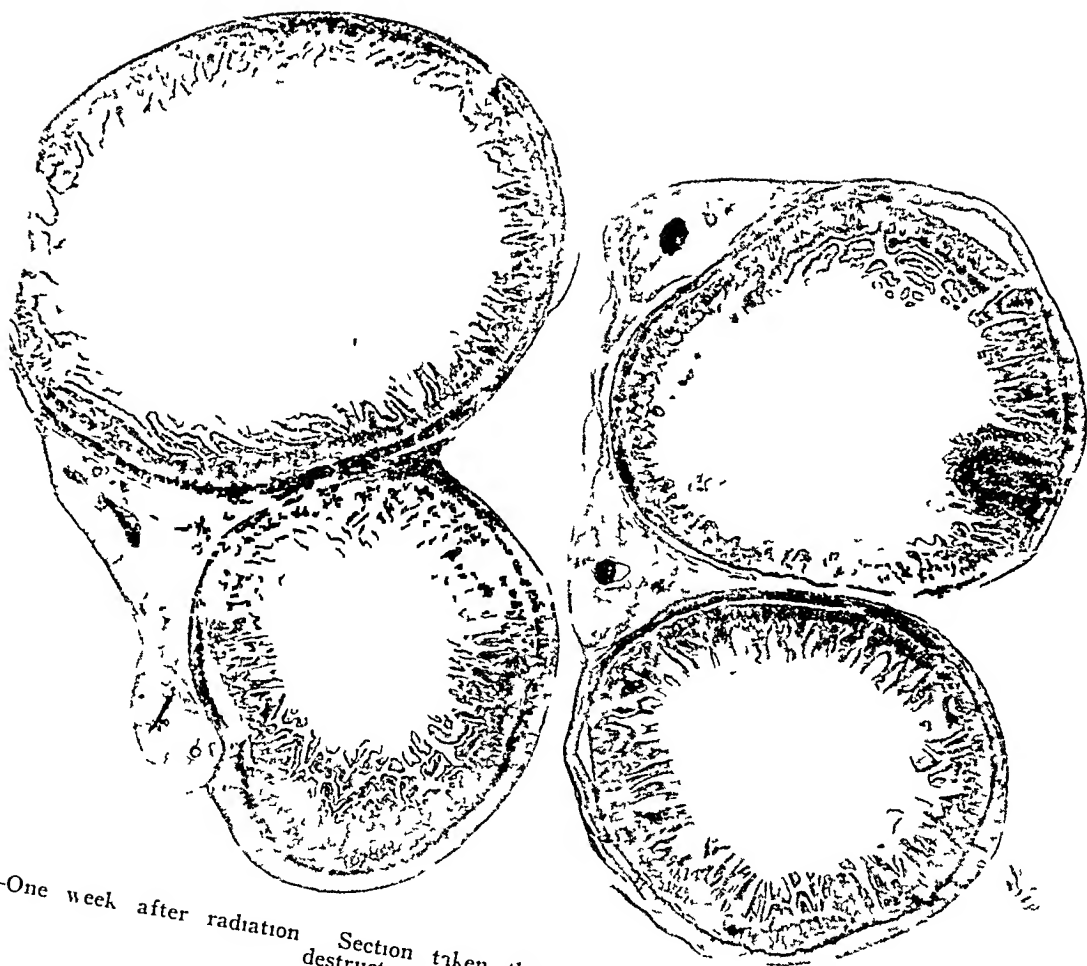


FIG 14—One week after radiation Section taken through adhesion destruction (Low power) Note extensive glandular



FIG 15—Same section as Figure 14 Photomicrograph, one week after radiation, through adhesion showing firm agglutination with fibrin and beginning organization at the margins (High power)

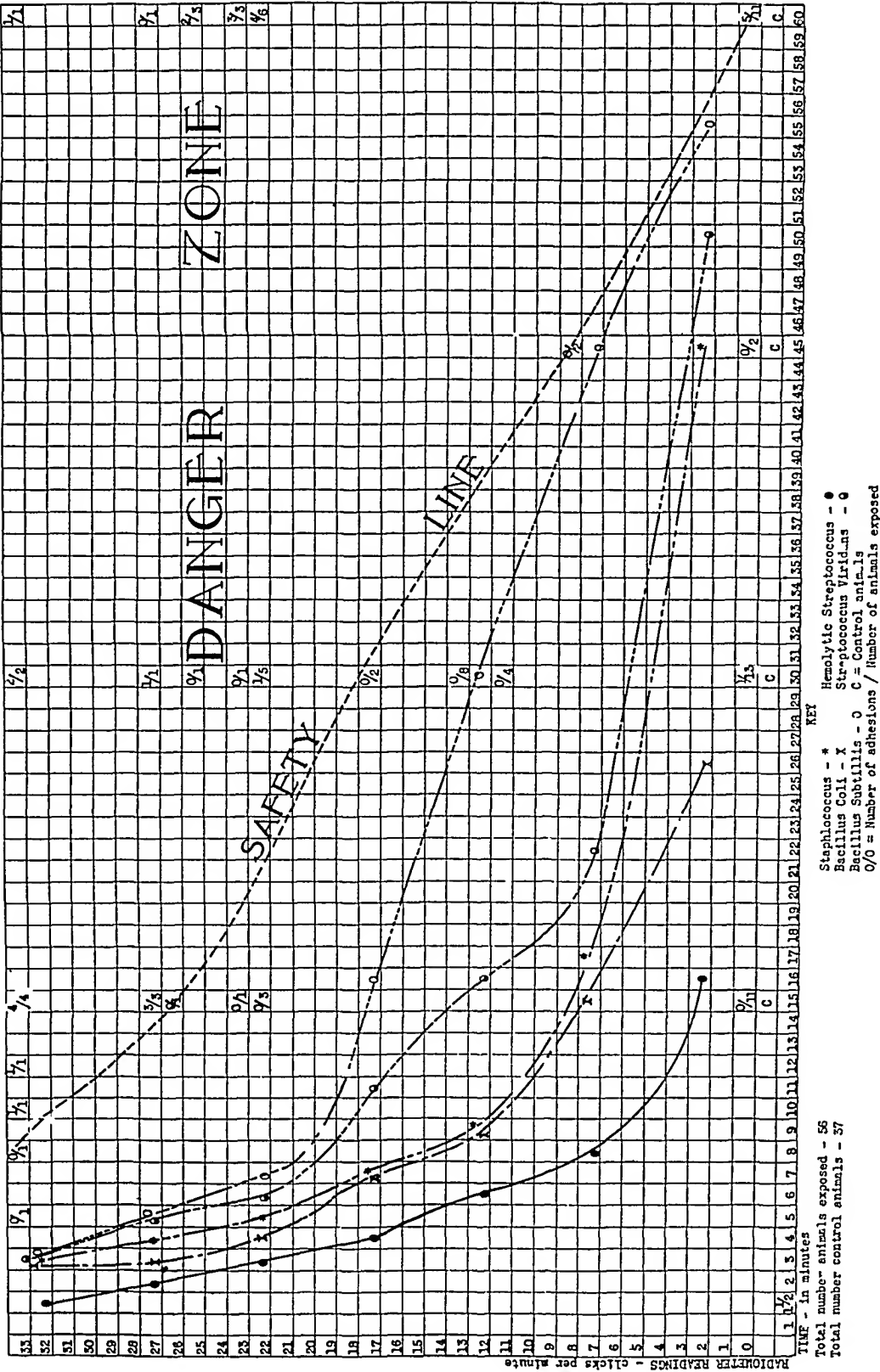


FIG 16—Comparative graph showing intensity required to produce adhesions in guinea pig viscera (1 click = 1.71 microröntgens per square centimeter at 1 meter)

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as the square is seen to have a sharp outline. The average of a number of similar experiments indicated complete bactericidal action for *Staphylococcus aureus* to be five minutes at 22 clicks per minute. It will be seen that the

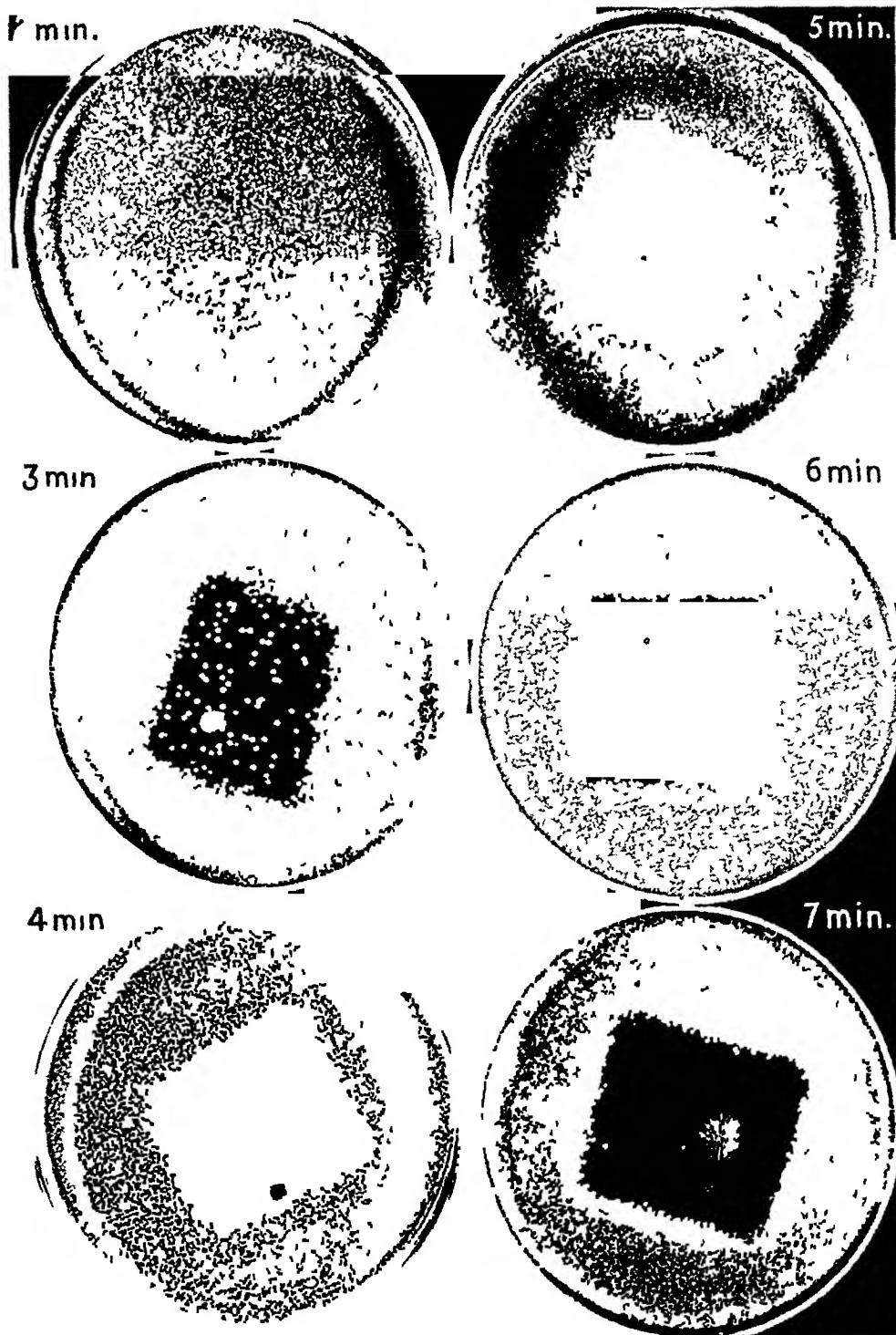


FIG. 17—Photographs of seeded plates showing bactericidal effect on *Staphylococcus aureus*. Intensity 22 clicks per minute—end point six minutes.

lethal points for all organisms fall below the safety line so that there is an adequate margin of safety. It is evident, therefore, that one may still kill organisms on seeded plates with a lesser intensity than that which will injure guinea-pig viscera in the same period of time.

Our problem was to determine the effect of this relationship to the bac-

tericidal effect on organisms suspended in the air. Here we found confusing factors, such as variations in the air currents, size of droplets of organisms, and hazards to exposure from the organisms themselves. Many experiments were undertaken in an attempt to obtain consistent results, but it was not until a chamber was constructed, as is shown in Figure 18, that any significant data was obtained.

This apparatus consisted of a large upper chamber four feet square with a corresponding space below divided into two parts and separated from one another longitudinally by a partition. The side of one of the lower compart-

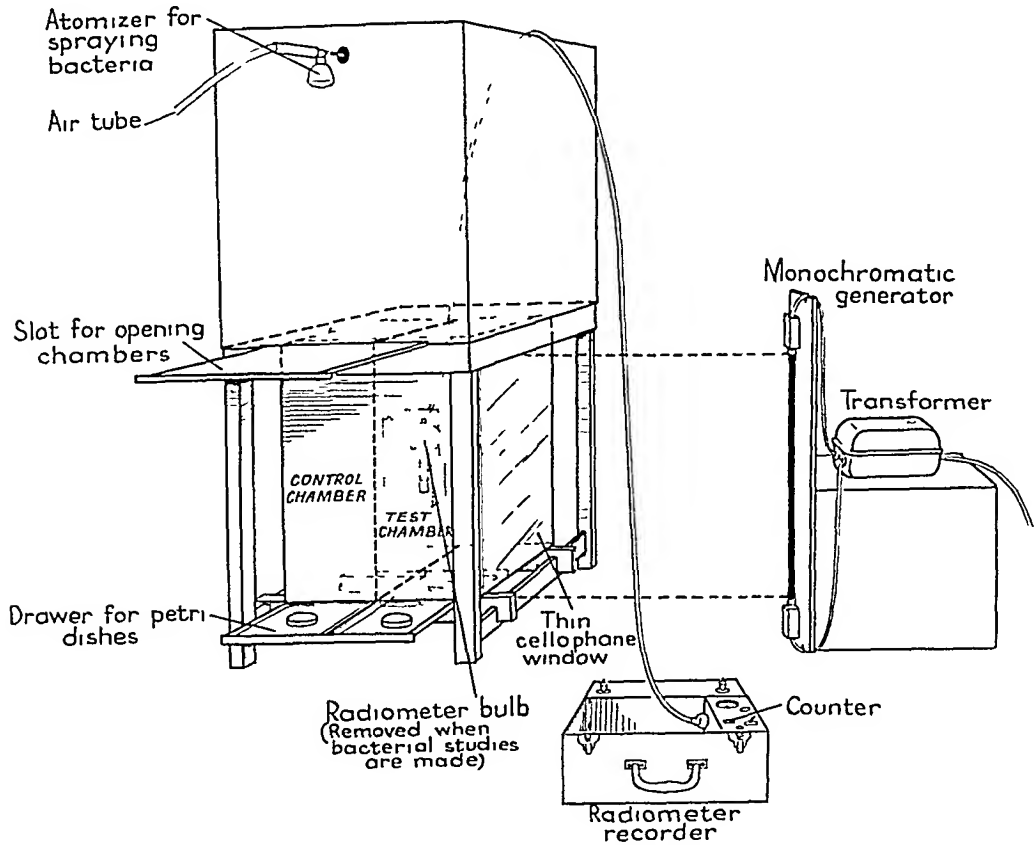


FIG 18—Showing the apparatus used in determining the intensity required to kill organisms in air

ments was made of a thin cellophane window in order to permit the passage of ultraviolet radiation from a monochromatic generator nearby. A drawer on the floor of the two lower compartments made it possible to expose Petri dishes and collect falling bacteria. Preliminary tests showed that an approximately equal number of bacteria fell and grew on the Petri dishes exposed in the drawers of the two lower compartments. The upper chamber was sprayed with 10 cc of a 24-hour culture of bacteria diluted 1:100, which represented approximately ten to 50 million organisms per cubic centimeter. It was found that one minute settling time of the bacterial spray in the upper chamber was necessary to evaporate the fluid part of the culture and prevent droplets from forming on the exposed plates in the lower drawers. The tops of the Petri dishes were opened after the radiation was discontinued,

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insuring the fact that the organisms were not destroyed after they had settled on the culture media of the dish. The plates exposed in the control chamber and those exposed in the radiated chamber were then compared.

The intensity of radiation was regulated by altering the distance of the monochromatic generator. It was found that there was not as definite an end-point of lethal action in these tests as there was in the exposure of the seeded plate. Some effect was present at as low an intensity as four clicks per minute. These tests were performed at different times so that the colony counts on the control plates vary considerably, though we may assume that the number of bacteria falling in the control and in the radiated chambers were the same in any given test. The relationships are shown in Figure 19.

	<i>Test</i>	<i>Control</i>
4 c /m	51 colonies in 1 minute	356 colonies in 1 minute
6 c /m	26 colonies in 1 minute	118 colonies in 1 minute
10 c /m	6 colonies in 1 minute	220 colonies in 1 minute
13 c /m	3 colonies in 1 minute	535 colonies in 1 minute
16 c /m	2 colonies in 1 minute	327 colonies in 1 minute

FIG. 19—Shows the effect of ultraviolet radiation on bacteria suspended in air

Employing this method of determining bactericidal power in air, variations were made in the time of exposure, time of settling, and intensity of radiation. We found that an intensity of 13 clicks per minute is required to kill bacteria falling a distance of three feet in one minute through the air, while it takes approximately nine minutes to kill the same type of organism on the seeded plate. It may be said, therefore, that, at this intensity, the radiations are nine times as effective in air as on the plate. If the intensity is raised to 16 clicks per minute the effect in the air is only six times as efficient as on the seeded plate.

Sharp⁵¹ also studied the bactericidal power in air of this monochromatic generator, by means of a rather complicated apparatus which forced artificially contaminated air, after radiation, through liquid culture media. This indicated absolute sterility because only one or two surviving organisms would cloud the media if they were not completely destroyed. He expressed the lethal intensity as 26,200 ergs per square centimeter, while Gates²¹ computed it in a similar manner as 30,000 ergs per square centimeter necessary to produce sterilization on the seeded plate. In a subsequent publication, Sharp⁵² stated that in his opinion the radiant energy required to kill various organisms on the seeded plate with the monochromatic generator should be used as an indication of the killing power in air. Our experiments show that almost complete sterility is obtained much more easily in the air than on the seeded plate.

In studying Hart's^{23, 24} publications it was felt that the intensity of the radiation that he used is greater than is necessary to reduce the organisms in the air and may be in the danger zone with regard to tissue injury. As his generators were of the same type which we have used, we have calculated that the intensity of Hart's radiation at a distance of five feet was approxi-

mately 33 clicks per minute. Our statistics indicate that this is almost three times as great as animal tissues may be safely exposed to for forty minutes. The actual time of exposure used by Hart was less as pads were probably used for protection.

Another apparent inconsistency was the fact that Hart found a blonde subject suffered only mild erythema after 80 minutes' exposure at this assumed intensity of 33 clicks per minute. We found that at this intensity slight erythema was produced on the inner aspect of the human arm of a blonde subject in six minutes, becoming marked at nine minutes and intense at 15 minutes. Other determinations with less intensity for longer periods indicated that one hour's exposure at 13 clicks per minute is the upper limit of safety to avoid erythema.

Practical Applications—Air contamination in an operating room may be determined in a number of ways. Wells⁶⁰ has devised a suction apparatus with which he may take samples of a given quantity of air in an operating room. The organisms contained therein are deposited directly on an agar surface where they may be cultured, but there must be considerable quantities in the air before significant results can be obtained.

A simple method, and one which is more indicative of the contamination of a sterile field as it actually occurs, is to expose a blood agar plate on or near the sterile field of operation. Incubation then will give an indication of what might be expected to fall on the operative wound. Some of these organisms may receive further radiation after they have fallen but no known experimentation has been devised to determine the quantity of organisms which will survive this combined radiation. Flushing of the wounds with sterile saline and subsequent culturing will give an indication of contamination but will not tell how many organisms will have produced it.

Colony counts made in our operating rooms with exposed Petri dishes showed a predominance of *Staphylococcus albus*, *Staphylococcus aureus*, both hemolytic and nonhemolytic *Streptococcus*, *Streptococcus viridans*, and *Staphylococcus citreus*.

As has been indicated before, the actual number of colonies varied considerably and depended upon the length of time of exposure, the position of the culture plate, and the number of people in the room, and their activity. In one instance a count of 280 colonies was obtained on one Petri dish in front of a group of students in 30 minutes. In another instance, in a different operating room, there were 66 colonies collected in 165 minutes. An average was made of ten determinations in one operating room and it was found that approximately 0.25 colony fell per minute per plate. In another operating room the average of 74 plates was 1.9 colonies per minute per plate.

Since the whole object of bactericidal effort in surgery is to reduce wound infection, we have, at this hospital, in the last 14 years, employed various improvements in technic, with the result of a lowering of wound infection in clean operative wounds from 4 per cent serious and 10 per cent trivial in 1925, to 0.5 per cent serious and 1.6 per cent trivial in 1938. Although this is rela-

tively low we believe every effort should be made to further reduce it. The only effort to combat air contamination during this period was to cover the instrument and dressing tables with canopies while they were not actually in use.

Our first endeavors to find an answer to the problem began in August, 1935, but it was not until January, 1937, that an installation was made in one of our operating rooms. This consisted of four one-foot quartz tubes jacketed with high transmission glass and containing dilute acetic acid between the glass tubes, previously described. This gave the maximum spectrum in the bactericidal range as indicated in Figure 5. Its intensity was very slight at the operative field, registering a total of only five clicks per minute with the tungsten bulb. This was reduced to zero when the operating team shielded the radiometer, but the reduction of the bacteria in the air was definite. Sixty-two plates were exposed in four cardinal positions, giving a total of 1,692 colonies collected in 955 minutes. This gives an average of 0.029 colony per minute per plate. Encouraged by the decrease in the number of viable organisms in the air and knowing that little if any tissue damage could come from radiation of such low intensity, various types of operations were performed under it.

Of over 100 major operations performed under these generators, 52 could be classified as clean cases and only one of these developed a minor skin infection. This, of course, is a very small number from which to draw any conclusions, but a careful study of the postoperative temperature reactions revealed no appreciable lowering of the average.

The operating room staff were provided with clear glass auto-driving goggles to protect their eyes from conjunctivitis. Ordinary spectacles did not protect them from the lateral rays. A simple starched helmet seemed to be all that was necessary to cover the head but this did not protect the forehead and areas left exposed by the mask. It is now recommended that a wide brim helmet be worn with a safari-type cloth to cover the back of the neck for more adequate protection.

Development of Present Application—We were not entirely satisfied with the previously described ultraviolet generator arrangement because we felt that there should be a sufficient concentration of radiation at the area immediately above the operative wound. We also felt that a wider distribution of a lower intensity of the proper radiations would be more efficient in reducing general air contamination. Although it was impossible to put a culture dish just where it would be most significant, dishes hung in baskets from the margin of the lighting unit usually gave the highest counts.

Effort was spent for several years to alter an illuminating unit to include an ultraviolet installation with a fan so placed that it would draw the air upward into the zone of the radiation. At the convention of the American College of Surgeons, in October, 1937, an operating room light was displayed which had no cover and made use of the 250 watt bulb with its heat-absorbing filter to promote an upward current of the air. The possibility of utilizing this

principle was at once appreciated, and after some time a unit was developed with an ultraviolet generator built in the lower margin. It was hoped that the gentle upward current of air would draw any bacteria in the air immediately above the operative wound slowly through the unit so that they might be destroyed while approximating the more intense radiation. First, it was necessary to determine whether or not the rising column of air was strong enough to make the bacteria rise. Culture plates were suspended from the unit with the top closed. Experimental studies were undertaken by spraying bacteria into the air and counting those which fell and grew on Petri dishes exposed at various levels between the unit and the operating table. The illuminating light was turned on, the top opened allowing the air to pass as it normally would, and another series of similar tests made. It was evident that there were many more organisms on the 52-inch plate when the top was closed and on the 12-inch plate when the top was opened, indicating that they were then drawn upward through the cone of the illuminating unit.

<i>Distance</i>	<i>No Illumination (Top Covered)</i>	<i>Illuminating Unit Operating (Top Open)</i>
12 inches	142 colonies	995 colonies
24 inches	143 colonies	391 colonies
36 inches	354 colonies	272 colonies
48 inches	511 colonies	312 colonies
52 inches	191 colonies	246 colonies

FIG. 20—Shows that air currents developed by the functioning illuminating unit draw bacteria upward.

It is apparent that the maximum intensity of the radiation should be above the operative site opposite the exhalations of the operating team, rather than directly on the wound itself. This was accomplished by the design of the reflectors in the illuminating light. At the operative site the intensity was considered to be optimum at 13 clicks per minute which has been calculated to kill 99.50 per cent of the organisms in air suspended for one minute. This is about the time an organism will take to drop a distance of three feet in still air. With this illuminating unit and its ultraviolet generator, if the organisms were not drawn through it and killed, the air currents would suspend them longer than one minute and practically insure their destruction. At this same intensity, our experimental animal studies have shown that guinea-pig viscera, which is probably more sensitive than human viscera, will not show changes after 40 minutes' exposure. This would probably exceed the actual time of continuous exposure of any one portion of a patient's viscera during any type of operation.

As has been indicated by Nisbet,⁴⁰ and confirmed here, the greatest contamination of the air occurs when the patient is being prepared by the many people who are hurrying about performing their duties, but at the same time stirring up a considerable number of organisms. It was felt that a greater intensity of radiation should be used at this time and gradually reduced as the activity in the room decreased. This would reduce the intensity of the radiation on the exposed viscera and would be adequate to keep the air relatively

sterile as the contamination decreased. It has been possible to install a regulating device on the ultraviolet generator which will regulate the intensity of radiation as required by an automatic time clock, or it may be manually controlled for unexpected prolongation of the operation.

Auxiliary units are placed on the walls in such a manner that sufficient intensity is developed throughout the room to keep the air relatively sterile. Each unit consists of a 30-inch generator with a control to regulate its intensity. It is therefore possible, with the use of a radiometer, to accurately determine the radiation in any part of the room and to raise it or lower it depending upon requirements.

Such an installation was set up in the laboratory and further bactericidal and adhesion determinations made. For example, eight animals were exposed

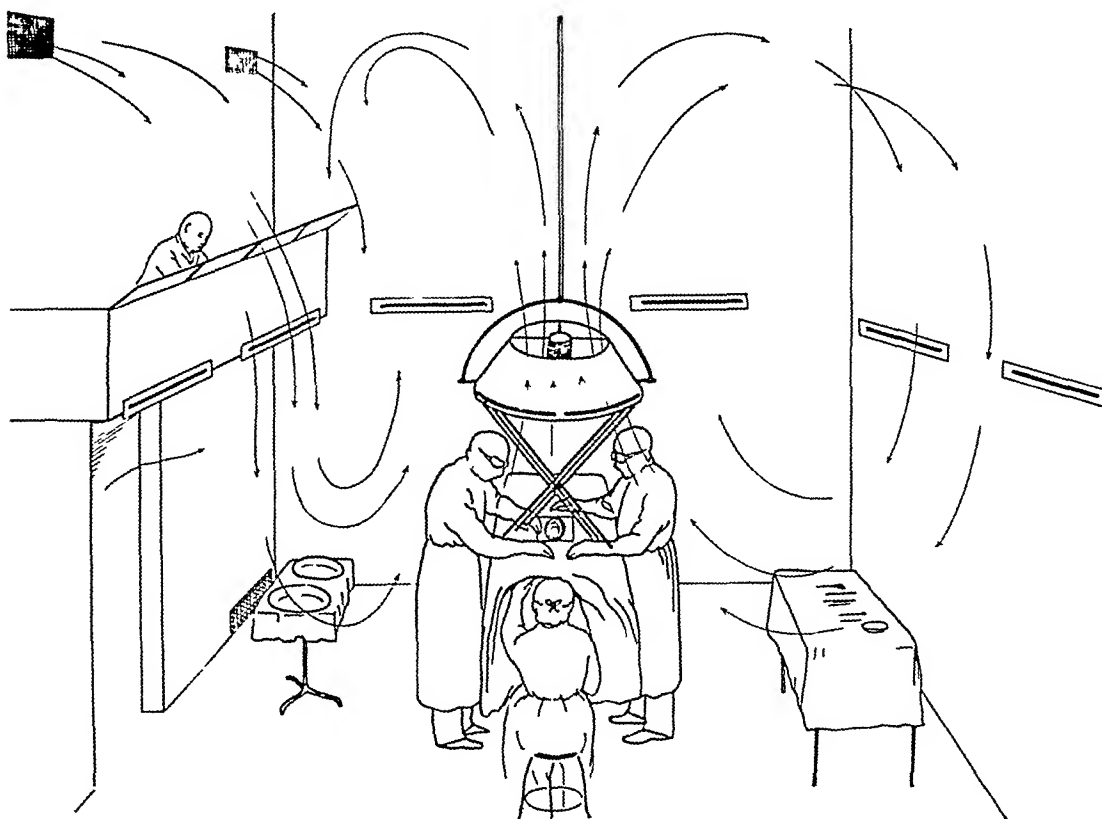


FIG. 21—Suggested type of installation with automatic intensity control for central unit. Note constant intensity over basins and instrument table.

at 13 clicks per minute for 30 minutes, and at autopsy, one week later, showed no evidence of adhesion. Bactericidal determinations at different stations in the room were made using seeded agar plates, similar to the previously described seeded plates. These findings have been recorded in Figure 16. It was felt, therefore, that this type of installation (Fig. 21) was safe and effective in controlling air-borne organisms and would not injure exposed viscera.

Effect on Wound Healing—The remaining question for consideration is the effect of ultraviolet radiation on wound healing. It is self-evident that a wound which received no bacterial contamination may logically be expected to heal more quickly and with less reaction than a contaminated wound even

though it did not suppurate. Any lessening of contamination will have a proportionately favorable effect. However, some observers believed that the radiation has a beneficial effect on the wound itself. As has been mentioned above, Beinhard⁶ employed sunlight in 1902, and later, an artificial source of ultraviolet radiation. Many other surgeons have used it empirically. Considerable interest was stimulated by Havlicek,²⁷ who employed a particular wavelength through a Woods' filter (366 Å) in treating cases of peritonitis. He stated that the action is not bactericidal but due to vasodilatation and subsequent prevention of thrombosis. This method and that of infra-red were studied by Bastien,³ who felt that a combination of the two was important.

Recently, Pollaczek¹¹ investigated, both clinically and experimentally, the use of controlled amounts of radiation on wound healing from a lamp produced by a "Woframel" burner. This gives a combination of infra-red, visible, and ultraviolet rays. He found that a small amount of radiation was definitely beneficial while a larger amount retarded wound healing.

Markuze³⁴ attributed the improvement in wound healing to a general effect more than a local effect, and found that the improvement over the controls was more demonstrable in older groups where epithelization is slower.

The direct action of various wavelengths on tissue cultures has been studied by Mayer and Schreiber.³⁵ They found that tissue cultures are not affected by wavelengths above 3,130 Å but are damaged considerably by radiations in the range 3,130 to 2,970 Å. Shorter radiations have less effect down to wavelengths below 2,800 Å where it remains approximately constant. This follows the erythema curve closely and may be due to histamine liberation.

In this laboratory, animal wounds, both clean and infected, were treated with the monochromatic generator. These, studied microscopically, showed an increase in vascularity, and the impression was also obtained that there was an advance in the stage of wound healing as compared with controls. No significant differences were appreciated in artificially contaminated wounds but the question remains whether or not some of the improvements in wound healing, described by Hart,²⁴ may be attributed to this effect as well as reduction in air contamination. However, the effect of the various wavelengths of ultraviolet radiation on healing wounds forms a study in itself and will be reported upon later.

CONCLUSIONS

(1) The unsterile air in the operating room is an important source of wound contamination.

(2) This contamination may be practically eliminated by the use of ultraviolet radiation, in the proper spectrum, with an intensity that will not injure animal tissue exposed for the time of a usual operation.

(3) An ultraviolet generator has been applied to an illuminating unit which concentrates this radiation in the most critical area, automatically controls the intensity of radiation, and, when bacterial concentration is greatest, produces the maximum effect.

(4) If the use of ultraviolet radiation for reducing air contamination in operating rooms is contemplated, surgeons are cautioned to determine that the quality of the radiation is in the most efficient part of the spectrum, and that the intensity is great enough to render the air relatively sterile and yet not so great that it will injure tissue for the period of time it will be exposed

BIBLIOGRAPHY

- ¹ Anderson, William T. Personal Communication
- ² Barnard, J. E., and Morgan, H. deR. The Physical Factors in Phototherapy. *Brit Med Jour*, **2**, 1269-1271, 1903
- ³ Bastien, Jacques. Les irradiations infra-rouges et ultra-violettes en chirurgie operatione. Le François Editeur, Paris, 1937
- ⁴ Bayne-Jones, S., and Van der Lingen, J. S. The Bactericidal Action of Ultraviolet Light. *Bull Johns Hopkins Hosp*, **34**, 11-16, 1923
- ⁵ Bedford, T. H. B. The Nature of the Action of Ultraviolet Light on Microorganisms. *Brit J Exper Path*, **43**, 437-441, 1927
- ⁶ Bernhard, O. Sonnenlicht behandlung in der chirurgie. *Nem Deutsch Chir*, **23**, Aufl Stuttgart, Enke 1917
- ⁷ Bovie, W. T. Action of the Extreme Ultraviolet of Tropical Sunlight on the Complementing Power of Serum. *J Med Res*, **38**, 335-344, 1918
- ⁸ Brewer, G. E. Studies in Aseptic Technique. *J A M A*, **64**, 1369-1372, 1915
- ⁹ Burge, W. E. The Action of Ultraviolet Radiation in Killing Living Cells Such as Bacteria. *Am Jour Physiol*, **43**, 429-432, 1917
- ¹⁰ Chaplin, Charles V. The Air as a Vehicle of Infection. *J A M A*, **62**, 423-430, 1914
- ¹¹ Clock, R. O. Bacterial Species Found in Nonsterile Surgical Catgut Sutures. *Surg, Gynec and Obstet*, **66**, 878-881, 1938
- ¹² Coblenz, W. W. Personal Communication
- ¹³ Coblenz, W. W. A Radiometric Investigation of the Germicidal Action of Ultraviolet Radiation. *Am Jour Electrotherap and Radiol*, **43**, 251-263, 1925
- ¹⁴ Coblenz, W. W. Methods of Evaluating Ultraviolet Radiation in Absolute Units. *Monthly Weather Review*, **64**, 319-321, 1936
- ¹⁵ Coblenz, W. W., Stair, R., and Hogue, J. M. The Spectral Erythemic Reaction of the Untanned Human Skin to Ultraviolet Radiation. Research Paper No 433, Bureau of Standards, Jour Res, **8**, 1932
- ¹⁶ Dandy, W. E. The Importance of More Adequate Sterilization Processes in Hospitals. *Bull Am Coll Surg*, **16**, 11-12, 1932
- ¹⁷ Davis, J. S. Importance of Adequate Masking During Operation. *ANNALS OF SURGERY*, **100**, 1008-1015, 1934
- ¹⁸ Drets, J. Mas, and y Diago, E. Madan. La septicidad del medio ambiente. Estudio bacteriologico del medio ambiente y su importancia relativa en la infeccion y curso postoperatorio de las heridas quirurgicas. *Rev de med y cir de la Habana*, **35**, 597-600, 1930
- ¹⁹ Editorial. Sterilization of Air in Operating Room. *J A M A*, **112**, 1072, 1939
- ²⁰ Ehrismann, O., and Noethling, W. Uber die bactericide wirkung monochromatischen lichtet. *Ztschr f hyg u Infektionskr*, **113**, 597-628, 1932
- ²¹ Gates, F. L. A Study of the Bactericidal Action of Ultraviolet Light. Reaction to Monochromatic Radiations. *Jour Gen Physiol*, **13**, 231-248, 1929
- ²² Halsted, W. S. Ligature and Suture Material. The Employment of Fine Silk in Preference to Catgut. *J A M A*, **60**, 1119-1126, 1913
- ²³ Hart, Deryl. Sterilization of Air in Operating Room by Special Bactericidal Radiant Energy, Results of Its Use in Extrapleural Thoracoplasties. *Jour Thoracic Surg*, **6**, 45-81, 1936

- ²⁴ Hart, Deryl, and Sanger, P W Effect on Wound Healing of Bactericidal Ultraviolet Radiation from a Special Unit—Experimental Study Arch Surg, 38, 797-805, 1939
- ²⁵ Haylicek, Hans Die verwendung des woods chen lichtes fur diagnose und schmerz betanlung bei operationem Beitr z Klin Chir, 154, 254-266, 1931
- ²⁶ Henri, V Comparaison de l'action des rayons ultra-violetts sur les organismes avec les reactions photochimique simples et complexes Compt rend d soc d Biol, 73, 323-325, 1912
- ²⁷ Hibben, Samuel G, and Blackburn, P W Sterilization by Ultraviolet Radiation Electrical Engineering, 57, 455-459, 1938
- ²⁸ Holtz, P Die entstehung von histamin aus histidin durch bestrahlung Arch f Exper Path u Pharmakol, 175, 97-103, 1934
- ²⁹ James, Robert F Personal Communication
- ³⁰ Kocher Eine einfache methode zur erzielung sicherer asepis, Corr Bl F Schweiz Aerzte Basel, 18, 3-20, 1888
- ³¹ Laurens, Henry The Physiological Effects of Radiant Energy The Chemical Catalog Company, 1933
- ³² Lister, Sir Joseph Address in Surgery Brit Med Jour, 225-233, August 16, 1871
- ³³ Major, C B, and Wilder, T S Air-Borne Infection and Air Sterilization (A Preliminary Work) Hospitals, 11, 87-90, November, 1937
- ³⁴ Markuze, K P Therapy of Wounds with Quartz Lamp Sovet Khir, 4, 40-44, 1933
- ³⁵ Mayer, E, and Schreiber, H Die Wellenlangenabhangigkeit der Ultra-violett-wirkung auf gewebeulturen ("Reinkulturen") Protoplasma, 21, 34-61, 1934
- ³⁶ Meleney, F L, and Stevens, F A Postoperative Hemolytic Streptococcus Wound Infections and Their Relation to Hemolytic Streptococcus Carriers among the Operating Personnel Surg, Gynec and Obstet, 43, 338-342, 1926
- ³⁷ Meleney, F L, and Chatfield, M The Sterility of Catgut in Relation to Hospital Infections Surg, Gynec and Obstet, 52, 430-441, 1931
- ³⁸ Meleney, F L Infection in Clean Operative Wounds, Nine-Year Study Surg, Gynec and Obstet, 60, 264-276, 1935
- ³⁹ Newcomer, H S The Abiotic Action of Ultraviolet Light Jour Exper Med, 26, 841, 1917
- ⁴⁰ Nisbet, O M, and Brooke, J W Incidence of Air-Borne Bacteria in the Major Surgery of the Multnomah County Hospital Surgery, 4, 755-761, 1938
- ⁴¹ Pollaczek, Karl F Uber wundbehandlung mit kunstlichem licht Arch f klin Chir, 175, 696-708, 1933
- ⁴² Price, P B New Studies in Surgical Bacteriology and Surgical Technic, with Special Reference to Disinfection of Skin J A M A, 111, 1993-1996, 1938
- ⁴³ Rasero, R Influence of Ultraviolet Rays on Healing of Wounds and Ulcers Riforma Med, 38, 772-774, 1922 Ab J A M A, 79, 1644
- ⁴⁴ Rentschler, H C Personal Communication
- ⁴⁵ Rentschler, H C, and Nagy, R The Bacteriological Effect of Very High and Very Low Radiation Presented before meeting of American Association for Advancement of Science, Richmond, Va, December 29, 1938
- ⁴⁶ Rentschler, H C An Ultraviolet Light Meter Amer Inst Elect Engineers Jour, 49, 113-115, 1930
- ⁴⁷ Rollier, A Physiologic and Curative Action of Sunlight Medecine, 5, 676-678, 1924
- ⁴⁸ Russell, E H and W K Ultraviolet Radiation and Actinotherapy Edinburgh, Livingstone, 1933
- ⁴⁹ Scott, W W, and Birkhaug, K E Comparative Value of Metaphen (Mercury Preparation) in Alcohol-Acetone-Aqueous Solution in Preoperative Disinfection of Skin ANNALS OF SURGERY, 93, 587-597, 1931
- ⁵⁰ Seitz, E O Ultravioletstrahler und ihre biologische bewertung Strahlentherapie, 55, 598-613, 1936

- ⁵¹ Sharp, D Gordon A Quantitative Method of Determining the Lethal Effect of Ultra-violet Light on Bacteria Suspended in Air Jour Bact , 35, 589-599, 1938
- ⁵² Sharp, D Gordon The Lethal Action of Short Ultraviolet Rays on Several Common Pathogenic Bacteria Jour Bact , 37, 449-460, 1939
- ⁵³ Tinker, M B , and Sutton, H B Skin Disinfection with Special Reference to Use of Acriflavine J A M A , 88, 1560-1561, 1927
- ⁵⁴ Torraca, L Mountain Sunlight and Healing of Wounds Arch ital di chir , 3, 441, 1921
- ⁵⁵ Walker, I J How Can We Determine the Efficiency of Surgical Masks? Surg , Gynec and Obstet , 50, 266-270, 1930
- ⁵⁶ Walter, C W Reliable Control for Steam Sterilization Surg , Gynec and Obstet , 67, 526-530, 1938
- ⁵⁷ Waters, E G Adequate Surgical Masking , Problem and Solution Am Jour Surg , 32, 474-477, 1936
- ⁵⁸ Wells, W F On Air-Borne Infection—Study II Droplets and Droplet Nuclei Am Jour Hyg , 20, 611-618, 1934
- ⁵⁹ Wells, W F and M W Air-Borne Infection, Sanitary Control J A M A , 107, 1698-1703, 107, 1805-1809, 1936
- ⁶⁰ Wells, W F Apparatus for Study of Bacterial Behavior of Air Am Jour Pub Health, 23, 58-59, 1933
- ⁶¹ Westinghouse Photo-Electric Recorder Acceptable Report of Council on Physical Therapy J A M A , 104, 315-316, 1935
- ⁶² Whipple, A O Use of Silk in Repair of Clean Wounds ANNALS OF SURGERY, 98, 662-671, 1933
- ⁶³ Whipple, A O , and Elliott, R H E, Jr Repair of Abdominal Incisions ANNALS OF SURGERY, 108, 741-756, 1938

THE MILLER-ABBOTT TUBE AS AN ADJUNCT TO SURGERY OF SMALL INTESTINAL OBSTRUCTIONS

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GASTRIC and duodenal suction has been used extensively during the past 20 years in the treatment of acute ileus. Kussmaul and Cahn¹ (1884) first used an elastic stomach tube for aspirating purposes and reported that this treatment would diminish the intra-abdominal pressure, reduce the size of the bowel proximal to the point of obstruction, and retard violent peristalsis. The duodenal tube was used by Westerman² (1910) for the distention of peritonitis, and McIver and his coworkers³ (1926) used it as a prophylaxis against postoperative ileus, after demonstrating that the source of gas in these cases was largely swallowed air. Wangensteen⁴ (1933) increased the effectiveness of the method by introducing the continuous suction-siphonage apparatus attached to the Levine gastroduodenal catheter. Wangensteen and Paine⁵ (1934) reported a low mortality in a large group of cases with acute ileus that were treated with continuous duodenal suction and surgery if necessary, and for the first time pointed out the type of cases that could be successfully deflated.

Wangensteen's⁶ classic work on bowel obstruction emphasized the importance of duodenal suction as an aid in the diagnosis as well as the treatment of these cases. He also recognized the obvious limitations of the method and stated that the most important objections were the inability to feed the patient by mouth, the continuous loss of electrolytes, and the failure to deflate the patient who had no peristalsis to regurgitate the fluid and gas into the duodenum. Abbott and Johnston⁷ adapted the Miller-Abbott tube⁸ to the management of cases with small intestinal obstructions, and reported that the limitations of duodenal suction were avoided.

Van Beuren and Smith⁹ found that the mortality for acute ileus in this hospital dropped from 66 per cent during the five-year period of 1919-1924 to 29.6 per cent in 1932-1937. During the more recent period, continuous duodenal suction had been used in almost every case. In addition, the importance of replacing the fluids and electrolytes lost by vomiting and suction was generally recognized, due to the observations of many investigators. Among the more important communications are those by Hartwell and Hoguet,¹⁰ Gamble and coworkers,¹¹ McIver,¹² and in this hospital, Atchley.¹³ This gratifying reduction in the mortality of acute ileus has been reduced to 5.9 per cent in 68 cases successfully treated with the Miller-Abbott tube during

the past 18 months. In fact, small intestinal intubation has proved such a valuable aid in the diagnosis and treatment of cases with small bowel obstructions that the Miller-Abbott method has been accepted in this hospital as a routine adjunct to the surgical management of all cases except those suspected of mesenteric vascular occlusion or strangulated bowel.

The Miller-Abbott Principle—Miller¹⁴ has recently described the development of the Miller-Abbott method of small intestinal intubation. His interest in intestinal intubation followed the report of Einhorn,¹⁵ in 1921, of a small jointed tube used for aspirating jejunal and ileal contents. This tube, however, proved unsatisfactory in Miller's clinic, as several days were often required to pass the tip of the tube into the terminal ileum of normal individuals, and because of the small caliber of the tube. Several modifications of the Einhorn tube were equally unsatisfactory, and it was not until 1934 that Miller and Abbott⁸ found a practical solution of the problem. Abbott, endeavoring to obtain kymographic records from an inflated balloon in the duodenum, found his efforts repeatedly frustrated by the rapid passage of the balloon into the jejunum. It immediately occurred to Miller and Abbott that a second larger tube for aspirating purposes could be attached alongside the smaller tube which controlled the balloon. They found that such an apparatus would reach the lower ileum within a few hours, and subsequently were able to have manufactured a double-lumened tube, one lumen for the control of the balloon and the other for aspirating gases and fluids.* This commercially prepared tube has been used exclusively in this hospital, but Abbott stresses the point that satisfactory double tubes can be prepared with the equipment available in most hospitals.

After much experimental work¹⁶ with the Miller-Abbott tube, Abbott (Miller¹⁴) adopted the technic to the management of cases with intestinal obstructions. The first 16 cases treated were reported by Abbott and Johnston,⁷ in 1938. Abbott,¹⁷ in Philadelphia, and Johnston and his coworkers,¹⁸ in Detroit, have continued the work in a large number of cases with amazing success.

Procedure—With the balloon folded umbrella-like upon the tip of the tube and generously lubricated, the tip is passed through the nose into the nasopharynx. The patient is given a drink of water and, as he swallows, the tube is passed rapidly into the stomach. Rarely has it been necessary to pass the tube through the nose and out the mouth before attaching the balloon. A 2 per cent cocaine spray is often used to shrink the nasal mucous membrane but no effort is made to secure complete anesthesia as the patient may complain of greater pain when sensation eventually returns.

After aspirating the gastric contents, the tip of the tube is placed at the cardia of the stomach by inflating the balloon (Abbott¹⁹) and withdrawing it until it is stopped by the cardiac sphincter. The balloon is deflated, continuous suction by a modified Wangenstein apparatus is started, and the patient al-

* The George P. Pilling & Son Company, Philadelphia, Pa.

lowed clear fluids by mouth. It is important to allow clear fluids by mouth immediately, otherwise the tip of the tube is arrested along the greater curvature of the stomach by the thick, tenacious gastric secretions. During the next four to six hours, the patient is instructed to push in the tube slowly from the 45 cm mark to the 75 cm mark, preferably, but not necessarily, while lying slightly on the right side. Occasional deep breaths aid in advancing the tip of the tube into the pylorus by changing the position of the stomach if more of the tube is pushed in on the expiratory phase of respiration. The nurse is instructed to detach the suction and lavage the stomach with 50 to 100 cc of warm water once or twice every hour to aid in decompressing the stomach.

This preliminary treatment, alone, affords so much relief that the patient will gladly cooperate if additional procedures are necessary in the fluoroscopic room. Approximately one-half the cases will pass the tube into the duodenum during this period. The position of the tip can be determined without fluoroscopic guidance by the tests described by Abbott. First, the return of the clear bile or small intestinal contents in the suction. Second, by observing the time required for water taken by mouth to appear in the suction bottle. If the tip is in the stomach, the return is instantaneous and clear, but should it have reached the duodenum, the water returns only after a delay and is usually bile-stained, never clear. Third,¹⁸ by observing the gentle, rhythmic resistance transmitted to a smooth piston Luer syringe when the balloon is inflated with the initial 20 cc of air if the tube is in the duodenum, in contrast to the lack of all sense of resistance when the balloon lies in the stomach.

If the tube remains in the stomach after this preliminary period, and the patient is too ill to allow fluoroscopic guidance, the procedure is repeated. This blind method of intubation has required as long as 72 hours in a patient dangerously ill with diffusing peritonitis. It is well to point out, however, that the benefits to be derived from early intubation far outweigh any temporary discomfort caused a sick patient by transportation to the fluoroscopic room, and the surgeons in this hospital now accept this procedure as a matter of course.

Our usual procedure, therefore, when the balloon remains in the stomach after the preliminary period of deflation, is to guide it to the pylorus under fluoroscopic control. An attempt is made to place the balloon at the pylorus with a wide, unkinked loop along the greater curvature of the stomach. This is accomplished by turning the patient on the right and left sides, as the occasion requires, and pushing in more tube as indicated. Manual pressure on the abdomen is seldom necessary. Not more than five to ten minutes should be spent attempting to pass the tube through the pylorus, as the position shown in Figure 1A is satisfactory.

The tube is fixed in this position with flamed adhesive tape across the upper lip, and the patient returned to his room. It is important that the tube be fixed with adhesive tape at the nose, in order to prevent it from being pushed backward instead of forward. The nurses continue their continuous suction and periodic lavage of the stomach, and the patient is allowed clear

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fluids by mouth. The tip of the tube in this position (Fig 1A) can only move forward for a distance equal to the unkinked loop in the stomach, and, as the stomach regains tone by deflation, the antral systoles invariably carry the tip into the duodenum within six to 24 hours. If fluoroscopic examination is indicated, only short, interrupted fluoroscopic exposures are necessary. There is always a temptation to push in more of the tube after the position shown in Figure 1A has been attained and the patient returned to his bed. If this is done, however, it only causes larger loops to form in the stomach

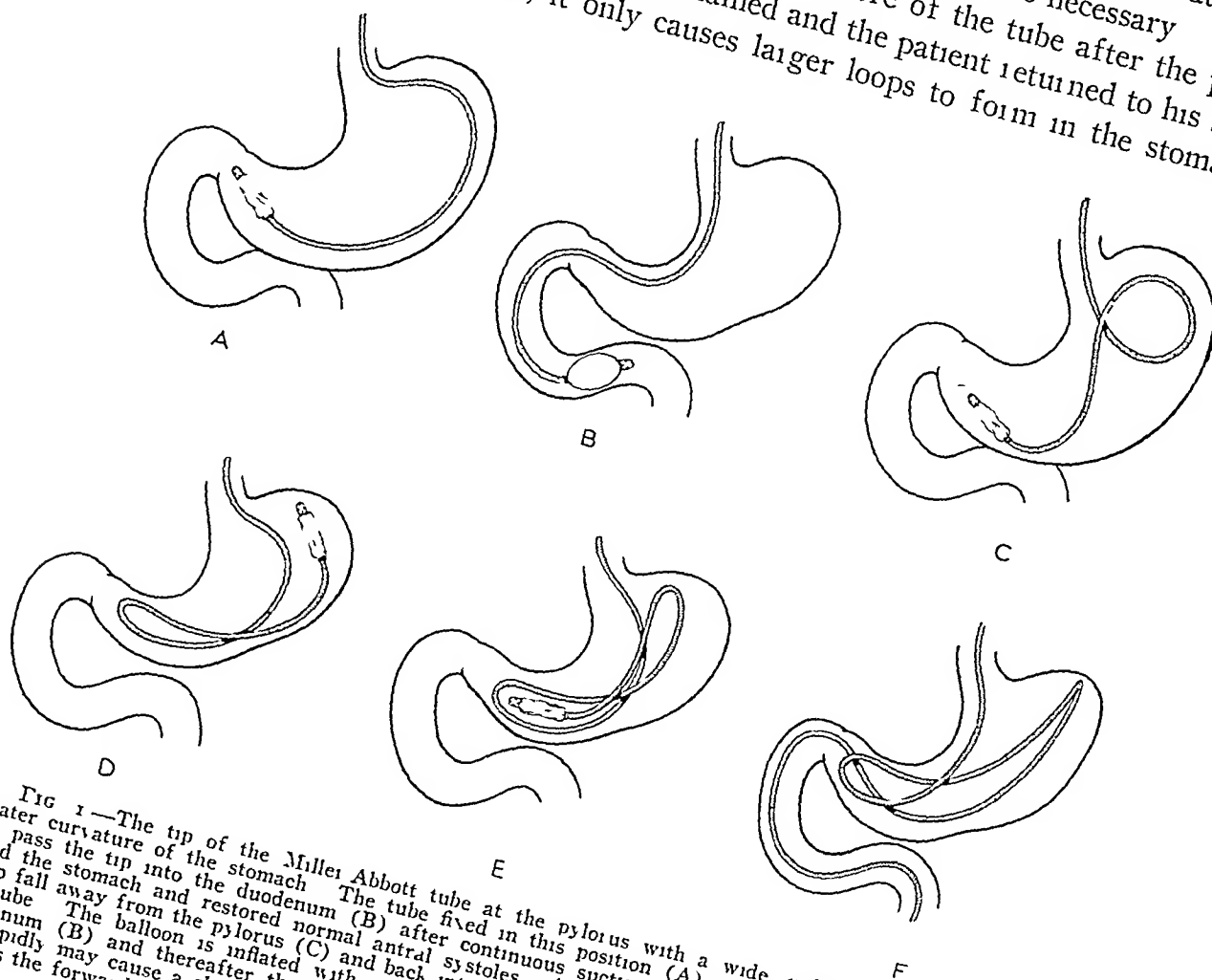


FIG 1—The tip of the Miller Abbott tube at the pylorus with a wide, unkinked loop along the greater curvature of the stomach. The tube fixed in this position (A) with adhesive tape at the nose will pass the tip into the duodenum (B) after continuous suction and repeated gastric lavage has deflated the stomach and restored normal antral systoles. Additional tube in the stomach will cause the tip to fall away from the pylorus (C) and back into the fundus (D) or cause snarling or knotting (E) of the tube. The balloon is inflated with 20 to 30 cc of air after it reaches the third portion of the duodenum (B) and thereafter the forward progress is almost automatic. Again, pushing in the tube too rapidly may cause a sharp angulation of the tube in the stomach (F) which occludes the lumen and retards the forward progress.

which tend to pull the tip away from the pylorus rather than advance it, or even cause snarling or knotting of the tube in the stomach as shown in Figures 1C, D and E. The straight unkinked loop along the greater curvature allows ample slack to reach the third portion of the duodenum when the tube arranges itself in the shorter course along the lesser curvature and into the duodenum (Fig 1B).

If there should be trouble in passing the tube across the spine to the pylorus, in case the stomach hangs across this structure in a saddle-bag manner, turning the patient more to the right side will usually overcome this difficulty. The method described by Abbott¹⁹ of filling the stomach with water, turning

the patient to the left side inflating the balloon and floating the tip across the midline, has been used successfully, but usually, this is not necessary

When the tip of the tube has reached the third portion of the duodenum and the balloon inflated with 20 to 30 cc of air, the forward progress of the tube thereafter is almost automatic. Continuous suction is maintained and periodic lavage is continued. Often the fluid content of an obstructed loop is too thick for the continuous suction to evacuate without the aid of dilution by lavage. The patient is instructed to push in an additional six inches of the tube every one or two hours, or whenever he feels the tube tugging against his nose as it attempts to advance forward. The vigorous peristalsis of mechanical obstructions often draws the tube forward spontaneously and rapidly. On the other hand the cases with paralytic ileus move the balloon forward very slowly. If additional tube length causes gagging when pushed into the nose, sufficient slack is present in the stomach. Additional coils in the stomach should not be allowed, as this may cause kinking (Fig 1F) or even prolapse a loop of the tube into the duodenum, thereby interfering with suction and retarding forward progress.

After the tube has entered the small bowel, the patient is allowed a fluid diet for the first one or two days and then offered a low residue diet. All fluids aspirated are carefully charted and the oral intake of fluid is supplemented by the subcutaneous or intravenous routes. Necessary electrolytes may be replaced by giving sodium chloride capsules by mouth. Abbott¹⁹ recommends that the amount should be approximately 5 Gm per liter of fluid aspirated by suction. Approximately two-thirds of the oral intake of fluid by mouth is returned by suction while the tube remains in the jejunum but only about one-third after it reaches the distal ileum. With the tube in the ileum it is usually unnecessary to give supplementary parenteral fluids.

The progress of the tube is followed by daily roentgenograms of the abdomen or short fluoroscopic examinations. When an obstruction is encountered, the nature and location of the lesion is studied by injecting 50 to 100 cc of barium suspension under fluoroscopic control. The tube is never removed until it has reached the point of obstruction in the small bowel, or until it has reached the cecum, even though the patient may be markedly improved clinically. This last point is very important, for many patients are completely relieved of symptoms after 24 hours of gastric or small intestinal suction, particularly in mechanical obstructions, where the vigorous peristalsis proximal to the point of obstruction causes a rapid reflux of the contents in the obstructed loops which can be evacuated by the tube far above the point of obstruction. However, unless the tube is allowed to advance, the nature and position of the lesion cannot be determined. Too often the tube has been removed because the patient was symptomless except for mild discomfort in the nose and throat, only to have the ileus recur, requiring a second intubation, always more difficult than the first. In cases with mechanical obstructions, even in the terminal ileum, the balloon may be passed to the point of obstruc-

tion within 24 to 36 hours, but in those with a paralytic ileus three to five days may be required to reach the cecum

Occasionally gastric distention persists after the tube has passed beyond the stomach and is controlling the small bowel distention. A gastric lavage may be necessary for a day or so in addition to the Miller-Abbott suction. Particularly is it advisable to lavage the stomach before operations. A few cases have presented mild gastric distention at exploration in spite of the completely collapsed small bowel.

Report of Cases—Our cases can be roughly divided into three clinical groups: (1) Noninflammatory obstructions. A Paralytic type. B Mechanical type. (2) Obstructions with peritonitis. (3) Obstructions with gangrene of bowel.

Groups 1 and 2 are discussed separately, as the presence of peritonitis with obstruction places them apart as especially difficult problems in intubation. The cases suspected of gangrene of the bowel are, of course, subjected to immediate operation and the tube used only in the short preoperative period while fluids are administered, and for the postoperative distention, if it occurs.

The distinction is made between "postoperative distention" and "postoperative ileus" by the response of each case to our previous routine treatment. We have reserved the term "postoperative ileus" for those cases with clinical distention that are not relieved within two or more days by prostigmin or pitressin, poultices and rectal treatments, and duodenal or gastric suction. Moreover, these cases have evidence of distended loops of small bowel with fluid level formation as seen radiographically. Any later reference to "routine treatment" in this paper implies that the various procedures mentioned here had been tried before intubation. In recent months the Miller-Abbott tube has been used prophylactically in many cases with mild postoperative distention which disappeared after 12 to 24 hours of gastric or upper small bowel suction, but these cases are not included in this report. All cases reported in this series faced exploration or enterostomy prior to intubation.

GROUP 1. *Noninflammatory Obstructions*—A Paralytic Type. Twelve cases which were treated in this group are listed in Table I. The immediate problem in these cases was one of maintaining the patient until distention was controlled and a diagnosis made without exploration.

CASE REPORTS—GROUP 1A

Case 1—P. H., No. 366,942 (Fig. 2). A male, age 59, developed bronchopneumonia in both lower lobes. There was a persistent ileus after ten days of routine treatment. A Miller-Abbott tube was passed into the duodenum on the eleventh hospital day, and deflation was complete after 36 hours. At that time the tip of the Miller-Abbott tube was shown, by fluoroscopic examination, to be at the cecum. The tube was removed and recovery was uneventful.

Case 2—N. I., No. 39,152. A male, age 59, with a transverse myelitis due to neuro-myelitis optica, had marked ileus for ten days without relief by routine treatment. The Miller-Abbott tube required seven days to completely deflate the small bowel and reach the cecum, but distention again appeared in the upper jejunum. The tube was withdrawn.

TABLE I
NONINFLAMMATORY OBSTRUCTIONS
Paralytic Type

Case No	Hospital No	Age	Cause of Obstruction	Time Required for Miller-Abbott Treatment						Result
				Duration of Ileus	Control Symptoms	To Pass Pylorus	X-Ray Guidance necessary	Reach Cecum	Total Time	
				Days	Hours	Hours		Days	Days	
1	P H No 366,942	59	Bronchopneumonia	10	6	3	No	2	2	Recovered
2	N I No 39,152	59	Transverse myelitis due to neuro-myelitis optica	10	12	24	No	7	18	Recovered
3	P H No 547,451	58	Postoperative hemorrhaphy Spinal pontocain	4	24	6	Yes	6	6	Recovered
4	P H No 76,608	32	Postoperative exploratory celotomy	4	12	12	Yes	4	4	Recovered
5	P H No 421,513	63	Postoperative cecorrhaphy and cecopexy	6	12	8	No	5	5	Recovered
6	P H No 548,256	29	Postoperative celotomy for division of adhesions	5	12	6	No	3	3	Recovered
7	P H No 571,349	53	Postoperative hysterectomy	9	10	8	No	3	3	Recovered
8	P H No 533,358	35	Postoperative suspension of uterus	4	48	6	Yes	5	6	Recovered
9	P H No 577,860	55	Postoperative colostomy—first stage abdominoperineal resection	3	48	36	Yes	4	4	Recovered
10	P H No 571,830	60	Postoperative—one-stage abdominoperineal resection	3	48	48	No	6	6	Recovered
11	P H No 440,306	60	Postoperative partial colectomy	7	48	4	No	5	6	Recovered
12	P H No 564,231	60	Generalized edema Ureteral calculus	4	4	1	Yes	6 hrs before and 2 days after exploration		Recovered

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to the duodenum and allowed to traverse the small bowel again. The neurologic symptoms gradually disappeared during this period and the tube was removed after 18 days of continuous suction. Recovery was slow but uneventful.

Case 3—P. H., No. 547,451. A male, age 58, developed severe ileus after a herniorrhaphy, performed under spinal anesthesia (20 mg. pontocaine in third lumbar space). The Miller-Abbott tube was passed on the fifth postoperative day after routine treatment had failed for three days. The barium studies on the eighth postoperative day showed dilated loops of ileum distal to the advancing tip of the tube. The cecum was reached on the ninth postoperative day and the tube removed. Recovery was uneventful.



FIG. 2.—Case 1. Bronchopneumonia with Paralytic Ileus. (A) Plain roentgenogram of abdomen showing distention prior to intubation. (B) After deflation with the Miller-Abbott tube. Barium injected through the tube shows an unobstructed bowel.

Cases 4 to 10, inclusive, had marked ileus following various surgical procedures. All were cured by one deflation with the Miller-Abbott tube after routine measures had failed.

Case 11—P. H., No. 440,306. A female, age 60, developed severe ileus after the resection of the sigmoid, end-to-end anastomosis, for carcinoma. Twenty liters of parenteral fluids were administered during the first five postoperative days. Generalized edema and ascites developed on the fourth postoperative day. Blood studies showed a high hematocrit (54 per cent) and a low serum protein (4.2 Gm. per cent). Cecostomy, performed on the fifth postoperative day, failed to function. Transfusions were helpful but failed to correct the abnormal fluid balance. The Miller-Abbott tube was passed into the upper jejunum on the seventh postoperative day and delivered large quantities (11 liters) of fluid during the first 48 hours, relieving the patient of nausea and vomiting. Routine treatments had failed prior to intubation. Roentgenograms of the abdomen at this time, however, showed many dilated loops of ileum distal to the advancing tip of the tube. The Miller-Abbott tube reached the cecum after five days of continuous suction, and the cecostomy began to function satisfactorily for the first time. Both the Miller-Abbott and cecostomy tubes were removed on the thirteenth postoperative day, when a barium suspension, injected through the Miller-Abbott tube, passed into the rectum after one hour. Recovery was uneventful.

TABLE II
NONINFLAMMATORY OBSTRUCTIONS
Mechanical Type

Time Required for Miller-Abbott Treatment									
Case No	Age	Cause of Obstruction	Dura- tion of Ileus	Control Symptoms	To Pass Pylorus	To Reach Obstruc- tion	Total Time	Opera- tions for Ileus	Result
			Days	Hours	Hours	Days	Days		
13 to 18 incl 19 & 20	43 20-58	Early postoperative adhesions *	5 2 (4-7)	22 7 (12-18)	19 0 (6-18)	3 0 (2-4)	8 0 (6-10)	3	{ All recovered
	45 & 27	Nonfunctioning ileocolostomy after resection of cecum							
21 to 44 incl 45	47 8 14-70	Late postoperative adhesions,† 2 Mos to 19 yrs after original abdominal operation	3 & 4 5 4 (3-30)	6 & 8 29 2 (4-18)	12 & 20 15 3 (1-60)	4 & 5 3 25 (2-5)	6 & 10 8 6 (4-21)	None 18	{ Both recovered All recovered
46	54	Lymphosarcoma of ileum	2	12	4	{ demonstrated	2	No	Recovered
47	60	Volvulus of cecum	2	12	3	1	4	Yes	Recovered
48	13	Intussusception—lymphosarcoma of ileum	3	12	2	12 hrs	7	Yes	Recovered
49	65	Carcinoma of ovary invading ileum	21	12	6	4	7	Yes	Recovered
			12	24	12	4	7	Yes	Recovered
50	59	Carcinoma of sigmoid invading ileum	14	48	24	5	9	Yes	Died P O Pneumonia
* Early postoperative adhesions followed two hysterectomies, two appendicectomies, one abdominalperineal resection and one exploration for division of late postoperative adhesions two years after hysterectomy									
† Late postoperative adhesions followed 12 hysterectomies, five appendicectomies, two colostomies one paritrl colectomy (sigmoid), one cesarian section, one marsupialization of ovarian cyst and one nephrectomy and ileostomy Five of these cases had multiple operations (2 to 10) One case was considered a failure because the patient was hysterical after six hours of intubation and the tube was removed before operation, without localizing the lesion									
Fluoroscopy was employed in 26 of the 38 cases									
Hospital Numbers for Cases 13 to 50 inclusive									
P H 513,557, P H 566,772, P H 433,379, P H 316,569, P H 532,728, P H 534,356, P H 555,755, P H 169,106, P H 225,460, P H 423,893, P H 393,502, P H 571,319, P H 564,154, P H 543,573, P H 466,386, P H 379,773, P H 528,402, P H 313,032, P H 589,165, P H 364,304, P H 316,569, P H 78,700, P H 375,309, P H 325,422, P H 508,322, P H 338,808, P H 322,123, P H 576,668, P H 525,422, P H 545,413, P H 550,180, P H 556,576									

* Early postoperative adhesions followed two hysterectomies, two appendicectomies, one abdominoperineal resection and one exploration for division of late postoperative adhesions two years after hysterectomy
† Late postoperative adhesions followed 12 hysterectomies, five appendicectomies, two colostomies one partial colectomy (sigmoid), one cesarean section, one marsupialization of ovarian cyst and one nephrectomy and ileostomy Five of these cases had multiple operations (2 to 10) One case was considered a failure because the patient was hysterical after six hours of intubation and the tube was removed before operation, without localizing the lesion

Fluoroscopy was employed in 26 of the 38 cases

Hospital Numbers for Cases 13 to 50 inclusive P H 559,621, P H 523,378, P H 235,467, P H 569,465, P H 578,634, P H 423,893, P H 513,557, P H 566,772, P H 433,379, P H 316,569, P H 532,728, P H 534,356, P H 555,755, P H 169,106, P H 225,460, P H 421,489, P H 393,502, P H 571,319, P H 564,154, P H 543,573, P H 466,386, P H 379,773, P H 528,402, P H 313,032, P H 589,165, P H 364,304, P H 316,569, P H 78,700, P H 375,309, P H 325,422, P H 508,322, P H 338,808, P H 322,123, P H 576,668, P H 525,422, P H 545,413, P H 559,180, P H 556,576

Case 12—P H, No 564, 321 A male, age 60, had had increasing ileus with crampy, colicky pains in the right lower quadrant for four days before admission. An appendectomy with drainage had been performed 15 years previously. Intubation was started and deflation was progressing satisfactorily but repeated blood counts showed an increasing white blood count, making exploration advisable for diagnosis. At exploration, the small bowel had been deflated and no cause for the ileus was found. Later roentgenograms of the abdomen showed a right ureteral calculus which had completely blocked the right ureter, accounting for the negative uranalysis done on admission. The tube was removed two days after exploration and recovery was uneventful.

GROUP I *Noninflammatory Obstructions*—B Mechanical Type. The 38 cases of mechanical obstructions have been mostly early and late postoperative adhesions. The other causes are listed in Table II. Many cases due to late postoperative adhesions were seen early without marked distention or dehydration, and any cases with an obvious hernia causing the obstruction have been subjected to immediate operation, without preliminary deflation, and are not included in this report. One death occurred in this group, due to postoperative pneumonia rather than ileus.

CASE REPORTS—GROUP IB

Case 13—P H, No 559,267 (Fig 3) Early Postoperative Adhesions. A female, age 58, developed increasing ileus for four days after a hysterectomy, in spite of routine treatment. The Miller-Abbott tube was passed on the fourth postoperative day and distention was completely relieved within 24 hours, although the abdominal roentgenograms showed the balloon still in the stomach. Intubation was continued, however, and the forward progress of the balloon was arrested in the left lower quadrant on the seventh postoperative day. Barium injected through the Miller-Abbott tube demonstrated an angulation of the ileum. The lesion was again demonstrated on the twelfth postoperative day, while the patient had remained symptom free on continuous suction and a low residue diet. Because the barium injected through the tube had been recovered in the stools, the surgeon elected to remove the tube without exploration. Distention recurred and nausea and vomiting again began on the sixteenth postoperative day. A second intubation was instituted and exploration showed the adhesion constricting the ileum in the pelvis at the position previously demonstrated by the roentgenologic studies. The tube was removed three days later, after the patient had had a normal bowel movement. Recovery was uneventful.

Cases 19 and 20—Nonfunctioning Ileotransverse Colostomy. Both of these cases, after resections of the cecum, developed severe ileus, apparently from edema at the site of anastomosis. Barium injected through the tube before removal demonstrated the patency of the bowel lumen and both cases made uneventful recoveries.

Case 21—P H, No 433,379 (Fig 4) Late Postoperative Adhesions. A female, age 47, had had repeated attacks of crampy abdominal pains, nausea and vomiting with distention for two years following the repair of a postoperative ventral hernia. All previous attacks had subsided spontaneously, but the present attack had continued for four days before admission. Deflation was accomplished with the Miller-Abbott tube after 48 hours of continuous suction. Barium studies demonstrated the point of angulation of the bowel beneath the old midline scar. The adhesions were divided without difficulty at exploration. The Miller-Abbott tube had advanced through numerous adhesions to within two feet of the ileocecal valve. Only the adhesions distal to the tip of the tube were divided. The tube was removed on the fourth postoperative day and recovery was uneventful.



FIG 3—Case 13 Mechanical Ileus Due to Early Postoperative Adhesions (A) Abdominal roentgenogram showing distention of small bowel four days after hysterectomy (B) The arrow shows the point of constriction in a partially deflated loop of ileum with the tip of the Miller Abbott tube overlying the adhesion (C) A pressure roentgenogram showing the point of constriction uncovered and in profile



FIG 4—Case 21 Mechanical Ileus Due to Late Postoperative Adhesions Roentgenogram of the abdomen 48 hours after intubation Barium injected through the Miller Abbott tube showing a partially deflated loop of ileum attached beneath a two year old lower right rectus scar

Case 44—P H, No 338,808 Late Postoperative Adhesions Requiring Prolonged Preoperative Preparation A female, age 70, had been followed for 15 years because of recurrent attacks of distention, nausea and vomiting which had subsided spontaneously on a liquid diet The present attack had lasted for one month and the patient was extremely emaciated and dehydrated Deflation with the Miller-Abbott tube required seven days A high protein-low residue diet was started on the fifth hospital day, and the patient gained approximately ten pounds in weight before operation on the eighteenth hospital day Parenteral liver and fluids, intravenous vitamins, and two blood transfusions were administered in addition to the food by mouth At exploration, no free peritoneal cavity was encountered in the right lower quadrant and only an ileostomy was accomplished The patient has been fairly comfortable for 12 months and has gained weight An ileocolostomy will be attempted later

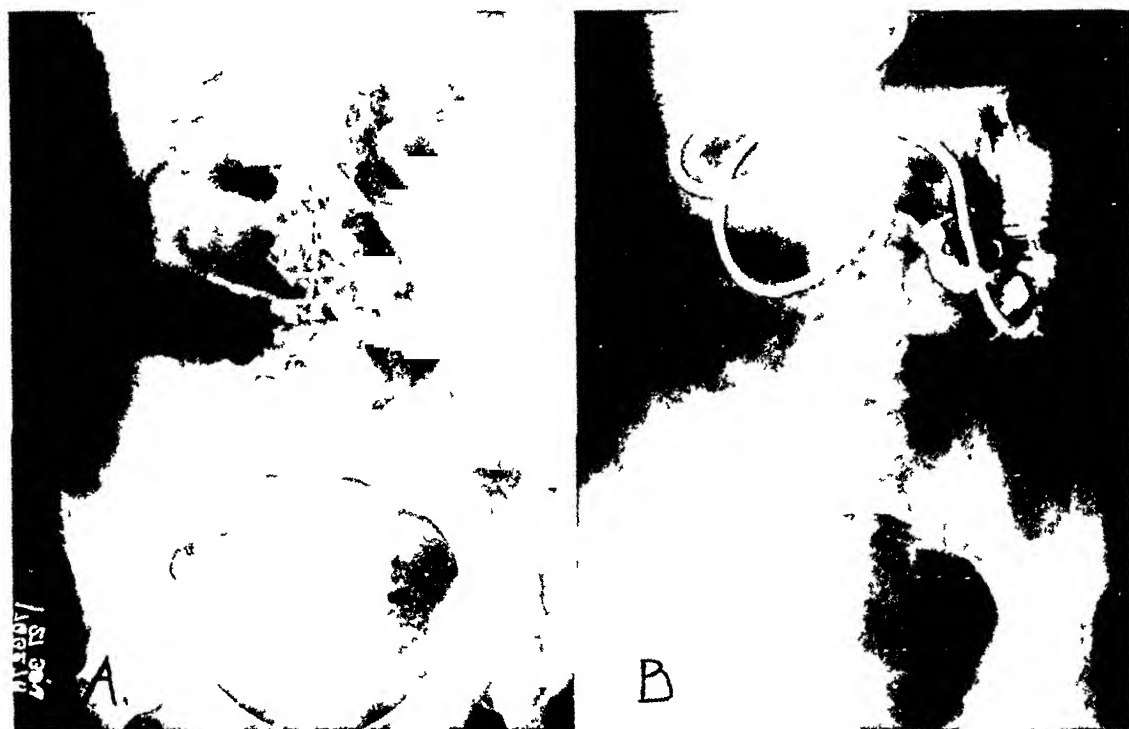


FIG 5—Case 47 Volvulus of Ileum and Cecum (A) Abdominal roentgenogram showing distention of small bowel, with an isolated loop in the left lower quadrant which did not deflate after 12 hours of small bowel suction with the Miller Abbott tube (B) This suggested a double obstruction, as in a volvulus, which was confirmed at operation

Case 45—P H, No 322,123 Incarcerated Pelvic Hernia The importance of examining all previous operative scars is illustrated in this case A female, age 40, had suffered from recurring attacks of distention for three years Seven years previously, the coccyx had been resected for a sarcoma All previous attacks of distention had subsided spontaneously, but the present ileus had continued for two days before admission Deflation was easily accomplished with the Miller-Abbott tube and the tip reached the cecum on the second hospital day without demonstrating the cause of the obstruction A barium enema was negative A small intestine study was started after the removal of the Miller-Abbott tube The patient accidentally coughed during the fluoroscopic examination and barium-filled loops were observed to protrude through the pelvic floor into the region of the old operative scar A pelvic hernia was confirmed and repaired at later operation

Case 47—P H, No 525,413 (Fig 5) Volvulus of Cecum A female, age 60, was admitted to the hospital, complaining of distention, nausea and vomiting of three days' duration A hysterectomy had been performed three years previously, for what was said to have been a fibromyoma of the uterus One year later, a firm mass was removed from the operative scar which proved to be carcinoma, presumably an implantation from the

previous operation. No previous attacks of distention had occurred. Intubation was started on admission, and the dilated loops of small bowel disappeared within 12 hours, but a palpable, isolated loop of distended bowel remained in the left lower quadrant. Exploration was advised by the radiologist and showed a large redundant cecum which was involved in a volvulus together with the terminal ileum. The twist was corrected and a cecostomy performed to anchor the cecum in the right lower quadrant. The tube



FIG 6—Case 48. Intussusception. (A) Lateral decubitus abdominal roentgenogram showing marked distention of the small bowel with fluid level formation. (B) Plain roentgenogram, four days later after deflation with the Miller Abbott tube. Barium injected through the tube demonstrates an intussusception of terminal ileum into cecum and ascending colon.



FIG 7—Case 49. Carcinoma of Ovary Involving Ileum. (A) Abdominal roentgenogram showing small bowel distention. (B) After deflation with the Miller Abbott tube showing dilated loop of ileum proximal to point of obstruction. (C) A pressure roentgenogram of the constricted lumen suggests that a mass is present within the wall of the bowel.

was removed on the fifth postoperative day, when barium injected showed a patent terminal ileum and cecum. Recovery was uneventful.

Case 48—P. H., No. 545,242 (Fig. 6). Intussusception. A male, age 13, was admitted for crampy, right lower quadrant pain, distention and melena of three weeks' duration. Distention and dehydration were marked, and a questionable mass could be palpated in the right lower quadrant. The Miller-Abbott tube was used for deflation,

while fluids and food were administered. Barium studies demonstrated an intussusception of the terminal ileum into the cecum after the patient had been greatly improved by four days of treatment. At operation, a resection was found to be necessary, and the tube was left in place for two days after operation. The mass in the bowel lumen proved to be a lymphosarcoma. The patient recovered from the immediate operation and was given extensive radiation but died six months later of generalized lymphosarcoma.

Case 49—P. H., No. 550,184 (Fig. 7). Carcinoma of Ovary Invading Terminal Ileum. An emaciated female, age 65, complained of recurrent attacks of distention, fever, and questionable melena following an appendectomy for a normal appendix 16 months previously. The symptoms antedated the operation by two months and had continued with increasing severity. Deflation with the Miller-Abbott tube required five days, at which time roentgenologic examination showed an obstruction of the terminal ileum, thought to be due to a neoplasm, since a filling defect could be seen in the wall of the bowel. At operation, a carcinoma of the right ovary was found invading and obstructing the terminal ileum. Ileotransverse colostomy was performed, without resection of the widespread tumor. The patient has remained symptomless and gained 20 pounds during the ten months following operation.

COMMENT—In cases with simple mechanical or paralytic ileus the Miller-Abbott method has made immediate operation unnecessary. Surgical treatment can be instituted after an accurate diagnosis is made, and the patient's condition greatly improved. Heretofore, it has been of little value to give barium by mouth to demonstrate the exact nature and the site of an obstruction in the presence of ileus, since without deflation, the barium will not reach the point of obstruction or will be so diluted by fluid as to be practically useless. Now, however, with deflation the exact site of the obstruction can be studied by barium injected through the tube and withdrawn later if desired. The movements of the balloon as it attempts to pass an obstruction give valuable information when observed fluoroscopically. Roentgenograms, made with a compression device,²⁰ may bring a point of obstruction into profile which would otherwise not be visualized, since there is often a tendency of the tip of the tube to override the site of obstruction in the barium filled loop just proximal to it (Fig. 3C). In the early postoperative cases, the intubation settled the difficult question as to whether the ileus was paralytic or mechanical in nature.

The patients with long-standing mechanical obstructions are usually in very poor condition when admitted. Protein foods can be given by mouth as deflation proceeds, and are far more effective than transfusions in restoring the low serum proteins often encountered in these cases. In less serious cases several explorations were avoided. However, when surgery is indicated, the location and often the nature of the lesion were known before entering the abdomen. The surgeon is also aided by having the tube to act as a guide, particularly when generalized adhesions are present. The resection of a pathologic bowel loop is made easier by reducing the size of the distended proximal loop by the preliminary deflation. The tube is left in place proximal to the anastomosis, with the balloon deflated, to control postoperative distention, which protects the suture line from disruption. The vital importance of

TABLE III
OBSTRUCTIONS WITH PERITONITIS
Miller-Abbott Tube Passed into Small Bowel

Case No	Hospital No	Age	Cause of Obstruction	Duration of Ileus	Mechanical Obstruction Demonstrated	Operation for Obstruction	Time Required for Miller-Abbott Treatment			Result
							To Pass Pylorus Hours	X-Ray Guidance	Total Time Days	
51	P H No 328,925	40	Diffusing peritonitis, probably due to pneumococcus	2	No	No	6	Yes	7	Recovered
52	P H No 506,110	22	Gangrene of appendix, with abscess	2	No	No	12	No	4	Recovered
53	P H No 568,465	49	Acute appendicitis	2	No	No	24	No	3	Recovered
54	P H No 369,231	70	Localized peritonitis, after cecotomy	3	No	No	24	No	5	Recovered
55	P H No 576,826	51	Acute diverticulitis, with localized abscess	3	Yes	No	24	Yes	4	Recovered
56	P H No 375,470	38	Acute appendicitis, with diffusing peritonitis	3	No	No	48	No	8	Recovered
57	P H No 558,220	32	Acute appendicitis, with diffusing peritonitis	3	No	No	24	No	3	Recovered
58	P H No 442,467	61	Acute cholecystitis, with localized peritonitis	3	No	No	24	No	4	Recovered
59	P H No 566,943	14	Acute appendicitis, with generalized peritonitis	4	Yes	No	72	No	10	Recovered
60	P H No 570,936	13	Acute appendicitis, with localized peritonitis	4	Yes	No	4	Yes	12	Recovered
61	P H No 580,822	51	Gangrene of appendix, with abscess	5	Yes	No	3	No	7	Recovered
62	P H No 563,298	17	Localized peritonitis	9	Yes	Yes	72	Yes	41	Recovered
63	P H No 541,310	37	Gangrene of appendix, with generalized peritonitis	10	Yes	Yes	24	Yes	19	Died
64	P H No 560,491	39	Generalized peritonitis	11	Yes	No	6	Yes	5	Recovered
			Purpura							
			Sepsis of unknown origin							
			Acute appendicitis, with localized peritonitis							

eliminating tension on the suture line by keeping the bowel collapsed cannot be overemphasized

It is of interest that none of these cases, or the ones observed by Abbott,¹⁷ showed a complete obstruction of the bowel lumen when, after deflation, barium was injected by means of the tube. Although the radiopaque material could always be seen to pass through the partially occluded lumen, this could not be taken as evidence that the obstruction would not again be complete when distention recurs and causes further kinking of a fixed loop. All the cases in this group which failed to allow the passage of the tube or a small balloon at a certain point after several days of continuous suction and in which an angulated segment could be repeatedly demonstrated roentgenologically, required surgery. In the inflammatory group, however, deflation often relieved the obstruction without allowing the tube to progress.

GROUP 2 Obstructions with Peritonitis—In the cases where the ileus is complicated by an inflammatory process involving the peritoneal cavity, whether the ileus be paralytic, mechanical or both, a special problem arises in intubation, which group will be reported in detail later. In this report, we only wish to show, by the accompanying tables, the type of case treated and the importance of early intubation, which is emphasized by observing the time relation between the duration of the ileus and the formation of mechanical obstructions.

The term "generalized peritonitis" is used only in those cases proved to have multiple abscesses by secondary operation or at autopsy. On the other hand, the term "diffusing peritonitis" is used to designate those cases with clinical signs of widespread peritonitis either at or after operation but where the widespread peritonitis was not confirmed by secondary operation or at autopsy.

Case 56—P. H., No. 328,925 (Fig. 8). A female, age 40, had signs of generalized peritoneal irritation following four days' illness beginning as an acute upper respiratory infection accompanied by generalized aching pains and temperature ranging between 102° and 103.6° F. When admitted on the fifth day of her illness, she complained of increasing distention and colicky abdominal pains, not localized, which had begun six hours previously. The lungs were clear and remained so. A throat culture showed on smear what was thought to be a pneumococcus but this was not substantiated by culture. Sulfapyridine, given (7 Gm.) for 24 hours, caused a dramatic fall to normal of both temperature and pulse, but the drug was discontinued because of nausea and vomiting. The ileus continued to increase for two days in spite of vigorous routine measures. The Miller-Abbott intubation was started on the third hospital day. Decompression was slow, but tenderness and pain disappeared as each segment of bowel was deflated. Sulfapyridine was again started on the fourth hospital day, due to a return of elevated temperature and pulse rate, and again there was a dramatic fall to normal. The tube was temporarily arrested in the right lower quadrant and an indefinite tender mass suggesting matted loops of distended bowel could be palpated in the region of an undeflated loop seen in the roentgenogram. All abdominal signs disappeared on the tenth hospital day, and barium, injected through the tube, passed rapidly into the cecum. The tube was removed after a one-day trial without suction. The sulfapyridine was injected as a suspension through the tube into the ileum when started the second time and suction discontinued for only 15 minutes after each

injection. A blood concentration of 5 mg per cent was found after 6 Gm of the drug had been administered in that manner. Recovery was slow but uneventful.

Case 60—P H, No 570,936 (Fig 9). A female, age 13, showed increasing distention two days after an appendectomy with drainage, for acute appendicitis with perforation and localized peritonitis. The Miller-Abbott intubation was started on the second postoperative day, at which time she was desperately ill with marked distention.



FIG 8—Case 56. Primary Peritonitis with Ileus. (A) Plain roentgenogram of abdomen after 24 hours of continuous gastric suction showing persistent distention of small bowel. (B) Three days later, the Miller-Abbott tube is arrested in the lower ileum with persistent distention distal to the tip of the tube. (C) Five days after (A), the small bowel is completely deflated and barium injected through the tube passes into the cecum.

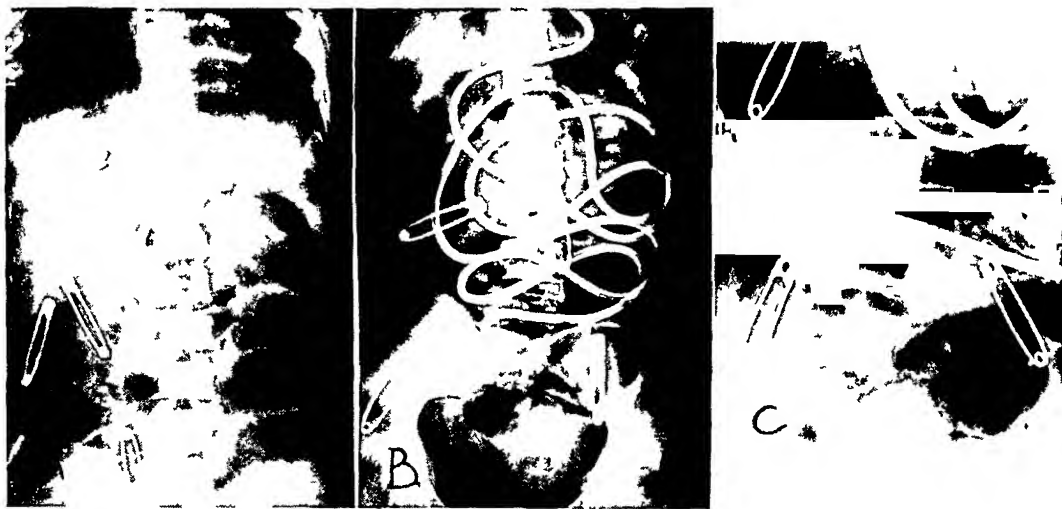


FIG 9—Case 60. Appendiceal Abscess with Acute Ileus. (A) Plain roentgenogram of abdomen showing the Miller-Abbott tube in the stomach after 24 hours of gastric suction. The small bowel is still distended. (B) The tube arrested in the region of the appendiceal abscess two days later. (C) Barium injected shows angulation with partial obstruction of the bowel. The obstruction disappeared after the infection subsided.

and fecal vomiting. The bowel was rapidly deflated after 48 hours, and fluids were thereafter given orally. A constriction in the bowel lumen was demonstrated in the terminal ileum on the fourth postoperative day. This was thought to be due to an angulation of the bowel by adhesions at the site of the residual right lower quadrant abscess. Distention was controlled by continuous suction above the site of obstruction until the patient had a normal stool on the twelfth postoperative day. During this time, the oral intake had been increased to include a low residue diet. The tube was removed on the sixteenth post-

operative day, after suction had been discontinued for four days without recurrence of the distention. Recovery was uneventful.

Case 62—P. H., No. 563,298 (Fig. 10). A male, age 17, was admitted gravely ill with generalized peritonitis. His history suggested the rupture of an acute appendix five days previously. On admission the Miller-Abbott tube was introduced into the stomach and continuous suction maintained thereafter. The patient received nine liters of fluid and blood during the first 24 hours before an adequate fluid balance could be obtained. At the end of this time, the right lower quadrant was opened and drained under local anesthesia but no attempt was made to remove the appendix. The patient's serious condition pre-

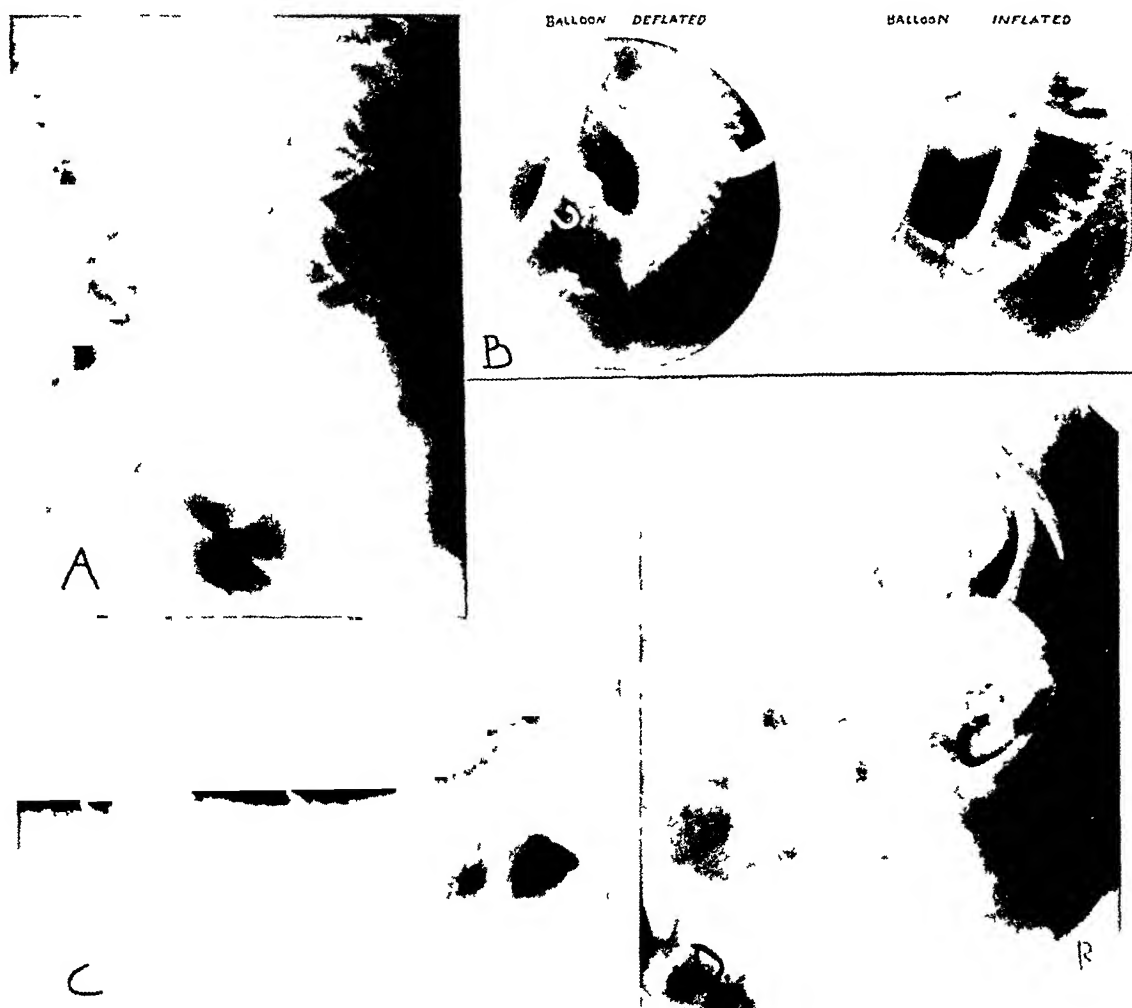


FIG. 10—Case 62. Generalized Peritonitis with Acute Ileus. Plain roentgenogram of abdomen on the eleventh hospital day showing the Miller-Abbott tube arrested in the left lower quadrant. (B) Pressure roentgenogram at the point of obstruction after barium was injected through the tube. On the left, the balloon is deflated and on the right the balloon is inflated. (C) Four days later, after two days without continuous suction the small bowel distention has recurred and the lateral decubitus abdominal roentgenogram shows the Miller-Abbott tube within the distended loops of ileum and jejunum. (D) A lateral abdominal roentgenogram to localize the point of obstruction before operation to release the adhesions.

vented fluoroscopic examination, hence the tube did not reach the duodenum until the fifth hospital day. Rapid deflation of the upper small bowel was accomplished thereafter, allowing the patient to take food and fluids by mouth. A second abscess, in the right upper quadrant, was drained on the ninth hospital day. The tip of the tube was shown to have stopped in the left lower quadrant and would not advance after several days of continuous suction. Barium studies on the eleventh hospital day demonstrated a partial obstruction of the ileum, thought to be caused by an angulation of the bowel by adhesions. These observations were confirmed by repeated examinations on the seventeenth and twenty-fifth hospital days. With continuous suction maintained, the patient was symptomless on a low

TABLE IV
OBSTRUCTIONS WITH PERITONITIS
Miller-Abbott Tube Failed to Reach the Small Bowel

Case No	Hospital No	Age	Cause of Obstruction	Dura- tion of Ileus Days	Mechanical Obstruction Demon- strated	Opera- tion for Ileus	Time Allowed to Pass Pylorus Hours	Fluoro- scopic Guidance Allowed	Result
65	P H No 532,728	14	Acute appendicitis, with generalized peri- tonitis	4	Yes	Ileostomy	48	Yes	Died
66	P H No 374,518	41	Generalized peritonitis, after repair of cystocele	4	No	Ileostomy	48	Yes	Died
67	P H No 249,200	64	Retropertitoneal abscess, after resection of cecum for Ca of cecum Diffusing peritonitis	5	No	Ileostomy	6	Yes	Died
68	P H No 537,264	51	Acute appendicitis, with abscess Local- ized peritonitis	6	Yes	Ileostomy	8	No	Recovered
69	P H No 552,089	51	Acute diverticulitis, with abscess Gen- eralized peritonitis	7	Yes	Cecostomy Ileostomy	12	Yes	Died
70	P H No 527,792	48	Generalized peritonitis Paratyphoid liver abscess	14	Yes	Ileostomy	24	Yes	Died
71	P H No 541,231	25	Acute appendicitis, with generalized peri- tonitis	14	Yes	Ileostomy	24	Yes	Died

residue diet and supplementary parenteral fluids were not required. The patient was tried without suction on the fifteenth day and again on the twenty-third day, but each time developed a recurrence of the ileus. Roentgenograms of the abdomen, made during the second trial two days after suction had been discontinued, showed the tube within distended loops of small bowel with fluid level formation in the lateral position. The partial obstruction was released by operation on the thirty-first hospital day. Fibrous adhesions were widespread, and it would have been practically impossible to locate the point of obstruction without the tube to guide the surgeon. Continuous suction was maintained until the thirty-sixth hospital day when rectal treatments returned a fairly normal stool. Suction was discontinued thereafter, and the tube removed on the forty-first hospital day. Appendectomy was performed 20 days later (the sixty-first hospital day). The patient eventually recovered after a long convalescence. No complication could be ascribed to the long intubation and, surprisingly enough, after the first two weeks, the patient tolerated the tube without complaint.

Case 64—P. H., No. 541,310. The one death in this group occurred in a male, age 37, who was admitted as "Henoch's purpura," after two weeks of septic temperature, purpuric manifestations and increasing distention. The ileus was severe on admission but responded promptly to Miller-Abbott intubation. Repeatedly, blood, stool, throat and sputum cultures failed to identify the organism. Blood agglutination studies were not significant. The Miller-Abbott tube controlled the ileus over a period of 18 days, but the septic temperature continued. An exploratory celiotomy, on the eighth hospital day, showed a few adhesions beneath an old right rectus scar, but the ileus was due to a widespread inflammatory process. Culture of the peritoneal exudate gave no growth. An ileostomy was performed but did not function when the Miller-Abbott suction was discontinued. The tube was withdrawn to the upper jejunum on three occasions and allowed to traverse and deflate the small bowel. Purpuric manifestations continued and the patient complained so bitterly of the tube that it was removed on the eighteenth hospital day. He died in shock two days later after a rectal treatment returned large quantities of bright red blood.

CASE REPORTS—GROUP 2

Case 65—P. H., No. 532,729. A poorly nourished girl, age 14, developed an acute ileus with peritonitis following appendectomy without drainage for acute appendicitis. Cultures of the peritoneal exudate showed a hemolytic streptococcus and *B. coli*. The Miller-Abbott tube passed into the third portion of the duodenum four days after operation, but the infected and edematous bowel was apparently powerless to advance the tube. An ileostomy, performed on the sixth postoperative day, did not function, and the patient died 12 hours later.

Case 66—P. H., No. 374,518. A widespread hemolytic streptococcus peritonitis followed a cystocele repair in a female, age 41. When first seen four days after operation, the patient was markedly distended and vomiting fecal fluid. The surgeon reported that one of the sutures might have entered the peritoneal cavity and the possibility of a compromised loop of bowel made exploration appear the logical procedure, but the patient refused a second operation. The Miller-Abbott tube was placed at the pylorus under fluoroscopic guidance three times during the next two days, only to have it removed by the patient in spite of special precautions. Operation was finally accepted on the sixth postoperative day, at which time ileostomy was performed, which, however, failed to function and the patient died 24 hours later.

Cases 54 and 70 were moribund when seen. Both had widespread peritoneal infection, and very little time was spent attempting to pass the tube. Ileostomy failed to function in either case.

Case 69 was in good condition when first seen. The obstruction was caused by a large pelvic abscess due to a perforation of the sigmoid following acute diverticulitis. Roentgenograms, 24 hours after intubation, showed the tip of the tube in the upper

jejunum with all distention apparently confined to the large bowel. A cecostomy was performed, and the patient's abdomen became soft within three hours. At operation, no dilated small bowel was seen, hence the Miller-Abbott tube was removed. He developed a recurrence of small intestinal distention and a second intubation could not be accomplished. An ileostomy failed to deflate the small bowel. The patient died of generalized peritonitis, with distention of the small bowel and bilateral pneumonia, two days after the second operation. Autopsy showed multiple points of obstruction in the ileum as well as the sigmoid. The small bowel obstruction would have been demonstrated if the Miller-Abbott tube had been allowed to continue downward at the first intubation.

Case 71—P. H., No. 541,231. A female, age 25, was admitted with a generalized peritonitis following acute appendicitis. Appendicectomy with drainage was performed on admission. Distention was fairly well controlled with duodenal suction until the eleventh hospital day, when routine methods gave no relief. The continual drain of electrolytes and fluids which occurs with duodenal suction made this patient an exceedingly poor risk for a second operation. Miller-Abbott intubation was attempted on the eleventh hospital day, but a single isolated loop of ileum had formed which would not allow the balloon to pass into the small bowel. Adhesions were divided at a second operation, on the twelfth postoperative day, and an ileostomy performed. The patient died 24 hours later.

The one survival in the group (Case 55, P. H., No. 537,264) had a mechanical obstruction at the site of a residual appendiceal abscess. An ileostomy was performed and functioned well, apparently, because the vigorous peristalsis proximal to the point of obstruction caused a reflex of the fluid and gas which could be evacuated by the ileostomy.

COMMENT—These patients are usually desperately ill, and one hesitates to subject them to the discomfort of fluoroscopic examinations, yet the passage of the tube without fluoroscopic guidance is time consuming and often impossible. All but one of our failures to pass the tube into the small bowel have occurred in this group. The results that follow early and successful intubation amply justify the procedure. Time consuming manipulation in the fluoroscopic room is not warranted, but the tip of the tube must be placed at the pylorus in order that it may progress spontaneously into the duodenum.

Our mortality figures for the two groups are not exactly comparable, since many of those in which the tube was passed successfully into the small bowel did not develop generalized peritonitis. As pointed out previously, however, five of our failures were in the first ten cases in which we recommended surgery early, due to a lack of experience in the method.

Observations upon many cases will be required before the true value of intubation is established beyond a question, but the dramatic suddenness with which these patients were converted from a condition of alarming distention and serious outlook to one of comparative well-being by deflation, and food and fluids by mouth, is striking. The ileus accompanying a peritonitis adds a serious complication to a patient already struggling to survive an overwhelming infection. The relief by intubation of distention and its pressure effected on the circulation of the bowel plays an important rôle in helping the patient toward recovery.

Although the evidence is slight at present, it would appear that early de-

flation will prevent the formation of mechanical obstructions that occur when the bowel is left distended during the fibropurulent stage of the disease. Constrictions in the bowel lumen have been repeatedly demonstrated radiographically in these cases. Only two, however, have required operative relief. All fatal cases showed massive adhesions causing multiple points of obstruction. If mechanical obstruction does occur, the tube offers the best method for keeping the patient symptom free until infection with its soft adhesions subsides or until the adhesions can be liberated by a secondary operation. Moreover, with the tube acting as an ileostomy, the patient is maintained in an adequate nutritional state on a low residue diet and fluids by mouth.

GROUP 3 Obstructions with Gangrene of the Bowel—The indiscriminate use of the Miller-Abbott tube in all cases of small intestinal obstructions would undoubtedly result in fatally delaying surgery in a certain number of cases with gangrene of the bowel. Care must be used in selecting the cases for intubation. Operation is advised in all cases of acute ileus with (1) A history of a sudden onset of pain which persists between crampy attacks, (2) where localized tenderness is elicited or a tender mass is palpable, (3) where the white blood count remains increased, and temperature and pulse rate do not return to normal after adequate fluids have been administered, and, finally, (4) in a few cases where the diagnosis is so obscure that exploration is necessary for the proper evaluation of symptoms. Immediate operation was advised in nine cases, four of which did not have gangrene of the bowel and which would probably have been benefited by preoperative deflation. Fortunately, no case with gangrene of the bowel has had operation delayed for intubation purposes alone. It must be remembered that cases with gangrene are encountered in only about 5 to 10 per cent of the total cases of acute ileus, and surgery alone has yielded very poor results.

TABLE V
OBSTRUCTIONS WITH GANGRENE OF BOWEL

Case No	Hospital No	Age	Cause of Obstruction	Duration of Ileus	Summary of Miller-Abbott Treatment	Result
72	P H No 546 956	44	Volvulus of ileum, with perforation. Localized abscess. Local peritonitis.	4 days	3 hrs before operation 18 days after operation	Recovered
73	P H No 551 181	67	Strangulation of ileum due to late postoperative adhesions	26 hrs	After resection only. Controlled distention for 16 days until second obstruction was corrected by second operation.	Recovered
74	P H No 531,770	14	Strangulation of ileum due to late postoperative adhesions	16 hrs	3 days after resection only	Recovered
75	P H No 482 415	40	Strangulation of ileum due to late postoperative adhesions	36 hrs	Profound shock when first seen 6 hrs before resection and until death 36 hrs later	Died
76	P H No 550 662	26	Strangulation of ileum due to adhesions of pregnant uterus	60 hrs	Profound shock when first seen 5 hrs before resection and until death 12 hrs later	Died

CASE REPORTS—GROUP 3

Case 72—P H, No 546,956 A male, age 44, was admitted with a five-day history of sudden onset of crampy abdominal pain, nausea and vomiting, diarrhea, and increasing distention. Operation was advised because of localized tenderness, elevated temperature, and increased white blood count. The Miller-Abbott tube was passed into the duodenum and continuous suction started while the patient was being prepared for operation. At operation, a volvulus of the ileum was found, with approximately six feet of gangrenous bowel which had perforated, producing a diffusing peritonitis around a localized abscess. Resection with end-to-end anastomosis was accomplished, and the wound drained with two large rubber tubes and a silk tampon. The Miller-Abbott tube was allowed to progress postoperatively, and fluids were given by mouth after the second postoperative day. Suction was discontinued on the eighth postoperative day, which was followed by a prompt recurrence of the ileus, which was again controlled by starting continuous suction. The tube was removed on the eighteenth postoperative day, when no ileus had occurred after a second two-day trial without suction. The recovery thereafter was uneventful.

Case 73—P H, No 551,181 A female, age 67, was admitted with a 26-hour history of sudden onset of crampy abdominal pain, increasing distention, nausea and vomiting. The temperature was elevated and the white blood count was increased. The patient had had a hysterectomy 20 years previously.

Immediate operation was performed, at which adhesions were divided, and the resection of a 20 cm loop of gangrenous ileum, which was found in the pouch of Douglas, undertaken. A Murphy button was used to effect the anastomosis. The Miller-Abbott intubation was started immediately after operation, and the patient was kept deflated and comfortable for four days, when trial without suction resulted in a recurrence of the ileus. Roentgenologic studies demonstrated a second obstruction, caused by the Murphy button's having been caught in a sharp angulation distal to the anastomosis. The patient remained comfortable, with suction continued, until the Murphy button could be removed on the sixteenth postoperative day. Recovery was slow but uneventful.

Case 74—P H, No 531,770 A female, age 13, three months after an appendectomy, was admitted with a history of sudden onset of crampy abdominal pain, and nausea and vomiting beginning 16 hours previously. The temperature was normal but the white blood count was increased. No distention could be noted in the abdominal roentgenograms, but a tender mass was palpable in the right lower quadrant. Operation was undertaken, at which a 12 cm loop of gangrenous ileum was removed, and an end-to-end anastomosis accomplished. The Miller-Abbott tube was passed immediately after operation. The abdomen remained soft during three days of small intestinal suction, at which time the patient passed a normal stool. The tube was removed and recovery was uneventful.

Case 75—P H, No 482,415 A female, age 40, was admitted with colicky epigastric pain, nausea and vomiting, without distention, for 24 hours' duration. Appendectomy had been performed for acute mesenteric lymphadenitis two months previously. The roentgenograms of the abdomen showed no evidence of ileus. Due to an increased white blood count, localized tenderness, and a questionable mass in the right lower quadrant—all present on the previous admission—the patient was admitted with a diagnosis of a recurrence of acute mesenteric lymphadenitis. Distention developed rapidly 24 hours later, and the patient went into profound shock. The Miller-Abbott tube was introduced into the stomach and gastric suction started while the patient was being prepared for operation. At exploration, a long loop of ileum was found strangulated by postoperative adhesions, which made a resection necessary. The patient became pulseless on the table. She responded to additional transfusions, but died in shock, 12 hours later. No attempts had been made to advance the Miller-Abbott tube beyond the stomach.

Case 76—P H, No 550,662 A female, age 26, was admitted to the Obstetric Service, with a history of sudden onset of crampy abdominal pain, nausea and vomiting, and increasing distention in the seventh month of her pregnancy. Two days later she

was delivered of a premature fetus, but her symptoms continued. When seen by the surgical consultant, two days after delivery, the patient was in shock, markedly distended, and had acute, generalized abdominal tenderness. The Miller-Abbott tube was passed into the duodenum and suction started while the patient was being prepared for exploration. At operation, old adhesions between the uterus and appendices epiploica of sigmoid were found encircling and strangulating about one-third of the small bowel, which required a massive resection. The patient died in shock six hours after operation.

COMMENT—The Miller-Abbott tube has a place in these cases in the usual stormy postoperative period. The first two cases were greatly benefited and the third made more comfortable during the immediate postoperative period.



FIG 11—Carcinoma of Splenic Flexure of Colon with Large Bowel Distention. Plain roentgenogram of abdomen showing persistent large bowel distention after 48 hours of continuous suction with the Miller Abbott tube in the terminal ileum.

The remaining two cases were in profound shock when intubation was requested, too late for either surgery or intubation.

Large Bowel Obstruction—In mechanical, large bowel obstruction with acute distention, our experience seems to indicate that cecostomy remains the treatment of choice. In five such cases, the Miller-Abbott tube was passed to the ileocecal valve, without relieving the large bowel distention (Fig 11), although decompression of the small bowel did relieve nausea and vomiting. However, the time required for the tube to reach the ileocecal region may well

allow a spontaneous rupture of a distended cecum and there is, therefore, some danger in delaying operation. Decompression of the large bowel probably fails because the ileocecal valve, for some reason, seems to act as a barrier to the passage of the tube when cecum is distended.

Notwithstanding the foregoing patients requiring large bowel resections, but who show no distention prior to operation, can be saved a preliminary cecostomy by passing the tube before operation. Continuous suction can be maintained after resection and fluid and food given by mouth, after the second postoperative day, without causing distention or discomfort. The tube can be kept in the ileum until the colostomy or the bowel anastomosis functions normally. Six such cases have been treated with gratifying results. These cases will be reported in detail in another communication.

TABLE VI

SUMMARY OF CASES OF SMALL INTESTINAL OBSTRUCTION TREATED WITH THE MILLER-ABBOTT TUBE AND SURGERY

Type of Obstruction	No of Cases	Operations for Ileus	Died	Mortality
Noninflammatory Obstructions	50*	27	1	2.0%
A Paralytic type	12	1	0	0
B Mechanical type	38	26	1	2.7%
* One case discontinued. Patient hysterical.				
Obstructions with Peritonitis	21	10	7	33.3%
Tube passed into small bowel	14	2	1	7.1%
Tube failed to pass into small bowel	7	8†	6	85.7%
Obstructions with Gangrene of Bowel	5	6†	2	40.0%
Total cases	76	43	10	13.2%
Total cases with tube passing into small bowel	68	35	4	5.9%

† Two cases required two operations for ileus.

Discussion—One of the most important requirements of the surgeon and radiologist in introducing the use of the Miller-Abbott tube is *patience*. It was difficult to secure cooperation of the surgeon in earlier cases because, heretofore, all cases with intestinal obstructions have been treated as a surgical emergency and the surgeon hesitated to accept a method, still in the experimental stage which often required a delay in operation as long as 24 to 48 hours. Apparently, many surgeons have tried to use the method and discarded it as impractical after failing to reach the duodenum within a few hours. Both Abbott and Johnston mention this difficulty in cases with distention, and point out that considerable time and careful attention are necessary for successful intubation. One surgeon recently stated that he had tried to pass the tube for 45 minutes but, of course, failed and has since discarded its use. Several of our own early failures were due to the fact that sufficient time was not allowed for the preliminary deflation of the stomach, but now, with growing confidence in the method, we do not hesitate to delay operation two days, if

necessary, to pass the tube into the duodenum. During this period, gastric suction alone will maintain the patient in as good or better condition if the fluids aspirated from the stomach are replaced in adequate amounts by parenteral routes.

SUMMARY

(1) Seventy-six cases of small intestinal obstruction have been treated with the Miller-Abbott principle, as originally reported by Abbott and Johnston. The procedure has been used (1) In paralytic ileus to deflate the bowel and demonstrate the patency of the bowel lumen, (2) in mechanical obstructions for deflation, diagnosis and localization of the lesion, (3) for the pre-operative administration of food and fluids by mouth, while the tube is serving the purposes of an ileostomy, and (4) for the control of postoperative distention in any type of case.

(2) A simple method of intubation is outlined which has been successful in passing the tube into the small bowel in 68 of the 76 cases. It is significant that five of the failures occurred in the first ten cases treated.

(3) Each case of small intestinal obstruction presents an individual problem in intubation, but the essential features used in the selection of cases are presented by dividing them into three clinical groups which require, for the most part, a similar method of procedure.

(4) The diagnostic value of the Miller-Abbott tube is graphically illustrated in the detailed reports of typical cases in each group.

(5) The therapeutic value of the Miller-Abbott tube is emphasized by the low mortality figure of 5.9 per cent in 68 cases in which the tube was successfully employed. Previous mortality figures from this hospital, reported by Van Beuren and Smith,⁹ range from 66.6 per cent (during 1916-1919) to 27.6 per cent (during 1932-1935).

(6) Cecostomy is the treatment of choice in cases with large bowel obstructions showing distention prior to operation, but unnecessary cecostomies may be avoided in cases requiring large bowel resections where there is no distention prior to operation.

(7) Gangrene should be suspected and an immediate operation recommended for all patients giving a history of a sudden onset of pain which persists between crampy attacks and who show localized tenderness over a palpable mass.

CONCLUSION

The Miller-Abbott method of small intestinal intubation is an *indispensable* aid to the proper management of small intestinal obstructions.

BIBLIOGRAPHY

¹ Kussmaul and Cahn, A. Heilung von Ileus durch Magenausspülung. Berl. klin. Wchnschr., 21, 669-685, October, 1884.

² Westerman, C. W. J. Über die Anwendung des Dauermagenhabers bei der Nachbehandlung schwerer Peritonitis Fälle. Zentralbl. f. Chir., 37, 36, 1910.

- ³ McIver, M A, Benedict, E B, and Chne, J W Postoperative Gaseous Distention Arch Surg, 13, 588, October, 1926
- ⁴ Wangenstein, O H Therapeutic Considerations in Management of Acute Intestinal Obstruction, Technique of Enterostomy and Further Account of Decompression by Employment of Suction-Siphonage by Nasal Catheter Arch Surg, 26, 933-961, June, 1933
- ⁵ Wangenstein, O H, and Paine, J R Treatment of Acute Intestinal Obstruction by Suction with the Duodenal Tube J A M A, 101, 1532-1539, November 11, 1933
- ⁶ Wangenstein, O H The Therapeutic Problem in Bowel Obstructions C C Thomas, Springfield, Ill, 1937
- ⁷ Abbott, W O, and Johnston, C G A Nonsurgical Method of Treating, Localizing and Diagnosing the Nature of Obstructing Lesions Surg, Gynec and Obstet, 66, 691-697, April, 1938
- ⁸ Miller, T G, and Abbott, W O Intestinal Intubation A Practical Technique Am Jour Med Sci, 187, 595-599, May, 1934
- ⁹ Van Beuren, F T, Jr, and Smith, B C Acute Ileus ANNALS OF SURGERY, 107, 321-339, 1938
- ¹⁰ Hartwell, J A, and Hoguet, J P Experimental Intestinal Obstruction in Dogs with Especial Reference to the Cause of Death and the Treatment by Large Amounts of Normal Saline Solution J A M A, 59, 82-87, July 13, 1912
- ¹¹ Gamble, J L, and Ross, S G The Factors in the Dehydration Following Pyloric Obstruction Jour Clin Invest, 1, 403-423, 1925
- ¹² McIver, Monroe A Acute Intestinal Obstruction Paul B Hoeber, Inc, New York, 1934
- ¹³ Atchley, D W, and Benedict, Ethel M The Distribution of Electrolytes in Intestinal Obstruction Jour Biochem, 75, 697-702, December, 1927
- ¹⁴ Miller, T G Intubation Studies of the Small Intestine IX Factors in the Maintenance of Physiological Conditions Rev of Gastroenterology, 4, 115, 1937
- ¹⁵ Einhorn, M A New Intestinal Tube with Remarks on Its Use in a Case of Ulcerative Colitis Am Jour Med Sci, 161, 546-550, 1921
- ¹⁶ Intubation Studies of the Human Small Bowel
- (a) Miller, T G, and Abbott, W O Experience with Double-Lumened Tube Ann Int Med, 8, 85-92, July, 1934
- (b) Abbott, W O, and Miller, T G Technic for the Collection of Pure Intestinal Secretion and for Study of Intestinal Absorption J A M A, 106, 16-18, January 4, 1936
- (c) Karr, W G, and Abbott, W O Chemical Characteristics of the Intestinal Contents in Fasting State and as Influenced by the Administration of Acids, of Alkalies and of Water Jour Clin Invest, 14, 893-900, November, 1935
- (d) Abbott, W O, Karr, W G, and Miller, T G Factors Concerned in Absorption of Glucose from the Jejunum and Ileum Am Jour Dig Dis and Nutrition, 4, 742-752, January, 1938
- ¹⁷ Abbott, W O The Treatment of Intestinal Obstruction and a Procedure for Identifying the Lesion Arch Int Med, 63, 453-468, March, 1939
- ¹⁸ Johnston, C G, Penberthy, G C, Noer, R J, and Kenning, J C Decompression of the Small Intestine in the Treatment of Intestinal Obstruction J A M A, 111, 1365-1368, October 8, 1939
- ¹⁹ Abbott, W O Personal Communication
- ²⁰ Golden, Ross, and Swenson, Paul C Experience with a Compression Device in Examination of the Alimentary Tract (In Press)

ACUTE APPENDICITIS

A TWENTY-YEAR CLINICAL SURVEY

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ACUTE APPENDICITIS still remains a mocking challenge to those who practice the art and science of medicine, in spite of all the advances made by surgery during the past two decades

More than 20 years ago, Murphy decried the apparent increase in the death rate of appendicitis when he forcefully stated "In looking up recently the hospital statistics on the results of operations for appendicitis, what mortality rate do you suppose I found? The average hospital mortality rate is just a little over 10 per cent! There is no excuse for a mortality rate of 10 per cent in appendicitis. The rate is simply shocking. These patients did not die because of the operation—do not misunderstand me—they died in spite of it. Procrastination was the cause of death—the almost criminal cause." And now, more than two decades after these memorable words were uttered—what do we find? An average mortality rate throughout the United States of over 10 per cent

Acute appendicitis continues to be the most frequent indication for major surgical intervention to-day. Yet it ranks second only to cancer among surgical diseases as a cause of death for all ages. According to Ochsner, in 1936, one person in the United States died every 29 minutes from appendicitis.

Vital statistics of the United States, for the year 1920, place the mortality rate for acute appendicitis at nine for each 100,000 of population, and at 14.3 per 100,000 for the year 1934, 18,129 deaths! The Metropolitan Life Insurance statistics indicate that the mortality rate of acute appendicitis rose from 10.6 per 100,000 for the period 1911 to 1914 inclusive, to 14.1 for the period from 1927 to 1930, inclusive. In New York City, the death rate from appendicitis averages about 14 per 100,000 of population yearly, 1,149 deaths occurring in New York City in 1934 were due to appendicitis.

Of 4,542 cases of acute appendicitis for the years 1921 and 1931, studied by Krech, in 14 Grade A hospitals, the operative mortality was 7 per cent. In these 14 excellent institutions, no appreciable decrease in the mortality rate from acute appendicitis had occurred in a decade—an appalling situation, an indictment against the medical profession!

While a review of the experience of the outstanding clinics shows figures

Submitted for publication January 13, 1939

better than a mortality rate of 7 per cent, in many cases, the toll is nevertheless too high. Thus, Seifert reports a total mortality for the decade, 1911 to 1920, to be 6.8 per cent at the Wurzberg University clinic and 3.5 per cent during the next decade (1922-1931) in 2,763 cases. Reviewing 2,000 cases of acute appendicitis, Swain reported an average mortality rate of 3.25 per cent, in 1934. Wevill and Wallace studied 8,265 cases at the Royal Infirmary at Edinburgh, and found that a mortality rate of 4.4 per cent had not significantly diminished over a 10-year period. Z. Muller performed 1,087 appendectomies over an 11-year period, and reported a mortality rate of 6 per cent for the acute type. Donaldson analyzed 2,700 cases of acute appendicitis at the Mercy Hospital in Pittsburgh, and found a death rate of 4.81 per cent. McKenna reports on 1,257 acute cases at St. Joseph's Hospital during the years 1922 to 1935, with fatalities reaching 5 per cent. In 1,734 cases studied at the Anderson County Hospital, Young found a total death rate of 4.3 per cent. In 1934, Stanton analyzed 16,424 cases with a death rate of 5.4 per cent, and found that 20 years prior, in 4,343 cases, the toll was 6.2 per cent. Jensenius analyzed 1,933 cases admitted to the Bespebjerg Hospital, Copenhagen, during 10 years. Of the 1,592 patients operated upon, 109 died, or 6.85 per cent. Rhodes made a clinical review of 1,000 consecutive cases of acute appendicitis at the San Francisco Hospital, and during the 10-year period, found an operative mortality of 3.6 per cent. Lazzarini recorded his observations on 800 cases of acute appendicitis operated upon in the Ospedale Maggiore of Milan, with a mortality rate of 1.2 per cent. In a survey of 10,000 cases treated at the Providence Hospital of Detroit, Davis reported a mortality rate of 3.8 per cent. A notable contribution is that by Guerry,¹⁴ who by delayed operation in 139 cases, was able to reduce the mortality rate from 10 per cent in diffuse peritonitis to 1.5 per cent. Reid, in a study of 2,806 cases, during the past 12 years, was able to reduce the rate from 9.5 to 5.4 per cent. Holden and Wells analyzed 3,526 acute cases in four hospitals in San Diego, with a death rate of 8.2 per cent. Reviewing 518 cases of the acute type in the University of Minnesota Hospitals, Sperling and Myrick found no appreciable decline in mortality had occurred during 20 years. Ray, more recently, reported a mortality rate of 2.1 per cent, in 886 cases of acute appendicitis operated upon at the New York Hospital.

SCOPE OF INVESTIGATION—Confronted with this array of figures from various clinics, and fully aware of the dissatisfaction of the profession with the results obtained, we were interested in studying the problem at our own institution. Our interest was two-fold. In an institution where the acute surgical service is very active and where operations for acute appendicitis over a period of 20 years totaled almost 9,000 cases, we were quite certain that instructive information would result from a detailed study, something constructive, to aid in dismissing the indictment of too high a mortality. In addition, we were interested to find out how we fared in comparison with other clinics—whether we were justified in continuing our time-tried methods or whether we should discard them.

This report represents every case of acute appendicitis operated upon at the Jewish Hospital of Brooklyn during the period of 20 years (January 1, 1915–December 31, 1934, inclusive). No case is included unless proven by pathologic examination to be one of acute appendicitis. Wherever some doubt existed as to the acuteness of the process, such case was omitted. However, in those cases where no appendicectomy was performed, the operative findings were such as to leave no doubt as to the cause of the peritoneal involvement.

TABLE I
REVIEW OF MORTALITY RATES AS REPORTED IN LITERATURE

	Period	Cases	Deaths	Rate
Krech ¹	1921 and 1931	4,662	318	7.0%
Seifert ²	1911–1920	1,350	92	6.8
	1922–1931	1,413	49	3.5
Swain ³		2,000	65	3.25
Wevill and Wallace ⁴		8,265	364	4.4
Muller ⁵		1,087	65	6.0
McKenna ⁷		1,257	63	5.0
Young ⁸		1,734	75	4.3
Stanton ⁹	1934	16,424	887	5.4
	1914	4,343	270	6.2
Jensenius ¹⁰		1,592	109	6.85
Rhodes ¹¹		1,000	36	3.6
Lazzarini ¹²		800	96	12.0
Davis ¹³		10,000	380	3.8
Reid ¹⁵		2,806	180	6.4
Holden and Wells ¹⁶		3,526	290	8.2
Sperling and Myrick ¹⁷		518	29	5.6
Ray ¹⁸		886	19	2.14
Morse and Rader (present report)	1915–1934	8,727	188	2.15
Totals		73,070	3,575	4.89%

In this 20-year period under consideration, 8,727 cases were examined in considerable detail. In order to standardize our statistical findings, we have employed certain terms, and to be sure of our terminology, a few definitions are essential.

In reviewing the literature, appendicitis, as presented in the acute form, may be either nonperforated or perforated. Nonperforated acute appendicitis our pathologist has classified as acute catarrhal, acute suppurative or acute gangrenous. Perforated instances of acute appendicitis we have subdivided into those where First, the perforation resulted in no local or diffuse peritonitis, but merely caused either the omentum, or some viscus to attach itself to the perforation and no peritoneal pathologic process was encountered macroscopically. Second, those perforated lesions which precipitated active peritoneal complications, such as local peritonitis, diffuse peritonitis. Third, definite abscess formation. In our presentation, we have purposely omitted the term "general" peritonitis and considered all forms of spreading peritoneal

inflammation diffuse, because of the possible error that any such term as general peritonitis may carry with it

Proper evaluation of statistics in acute appendiceal inflammation must carry with it the exact type of the acute process found, for the prognosis in the nonperforated variety certainly is much better than in the perforated form

The question may arise, of what value are statistical reports? We believe much can be learned, not in praising the general outcome, but in trying to analyze the cause of our failures, as we believe that the last word in the treatment of acute appendicitis has not yet been said. To be sure, operation as soon as the diagnosis is made is still an excellent treatment, but how shall we improve our results in the late, complicated, neglected cases? Can that mortality rate be reduced?

TABLE II
ANNUAL MORTALITY RATE, JEWISH HOSPITAL SERIES

Period 1915-1934, inclusive

Year	Cases	Deaths	Mortality Percentage	
1915	397	12	3.02	Average 2.73%
1916	442	19	4.29	
1917	404	13	3.21	
1918	405	9	2.22	
1919	417	12	2.87	
1920	394	9	2.28	
1921	393	13	3.30	
1922	400	9	2.25	
1923	448	11	2.45	
1924	433	6	1.37	
1925	398	4	1.00	Average 1.63%
1926	405	5	1.23	
1927	469	13	2.77	
1928	346	6	1.73	
1929	413	9	2.19	
1930	468	14	2.99	
1931	556	0	0.00	
1932	471	2	0.42	
1933	563	11	1.95	
1934	505	11	2.17	
Totals	8,727	188	2.15	

Acute appendicitis is not a finished subject. Of course, early operation would eliminate all our problems. Early operation carries with it the necessity of early diagnosis. Early diagnosis does not always carry with it the consent of the patient to submit to operation. Early diagnosis is not always a simple problem, and although acute appendicitis may be one of the most apparent diagnoses, yet there is not one of us who has not been chagrined to learn that we erred. It may be so protean in its manifestations, that the acuity of any surgeon or internist alike may be taxed to the limit. How to improve our

diagnostic acumen may require nothing other than the realization of how varied may be the clinical picture that presents itself. We hope, in the present review, to recognize every variety of appendicitis that has been encountered. As stated previously, the early variety requires very little to be desired, for we can, as have many others, boast of a mortality rate of less than one-third of 1 per cent, *i e*, one death in 300 cases. However, the story is far from encouraging in the late or perforated type, for here the deaths mount in our diffuse peritonitis group to one in three. It is this group that commands our particular consideration, and it is to this group that we shall chiefly concentrate our analyses.

We have, for completeness, analyzed our 20-year study in yearly considerations, *i e*, examined the improvement or lack of improvement during the period reviewed.

Sex incidence, to us, seemed a rather unimpressive factor, however, a detailed study was made.

Age—a rather important consideration, especially at the extremes of life—has been a factor that deserved complete investigation—in fact, so much so that we believe it warrants particular study. This analysis will be considered in detail in another communication.

The time element, too, is extremely important, not only in mortality outcome, but in morbidity results, and we have scrutinized, as carefully as possible, the results of those operated upon after a varying number of days of delay.

Temperature, pulse and laboratory data, too, have been extensively analyzed, as the reports attached will show.

There can be no doubt that the greatest single factor that determines the prognosis in acute appendicitis is early operation. All statistical reports bring home the fact, and anyone with surgical experience cannot but be convinced of this axiomatic conclusion. Yet the fact still remains that delay is rampant and the neglected case must be managed.

Our records are creditable, and we are gratified to report progress in the results, during the second decade under consideration, as compared with those of the first 10-year period.

Mortality Rate—Thus, we were able to reduce our mortality rate, for the decade 1925–1934, to 1.63 per cent, from 2.73 per cent, for the period 1915–1924. The number of cases of our total series was 8,727, 4,133 operated upon during the first decade of our series, and 4,594 during the second half of our 20-year period. There can be no doubt that statistics, in themselves, have little value, for the better results may merely represent good fortune in operating upon mildly afflicted cases. However, when we consider that over a period of 20 years, nearly 9,000 cases were encountered, surely some instructive conclusions should be developed.

In reviewing Table II, we were encouraged to find that during the year 1931, 556 cases were operated upon without a single death, and the following

year, 471 cases showed but two deaths, or two deaths in 1,027 cases, a truly remarkable record

Sex Incidence—We are of the opinion that sex has very little, or no significance in relation to the problem of acute appendicitis. However, in this statistical study, for the purpose of thoroughness, there are a few observations which we have noted. In common with the experience of others, we have found a slight preponderance of males over females (4,833 to 3,894), a ratio of approximately 5 to 4. There were 116 deaths among the males, a mortality percentage of 2.4. The female deaths numbered 72, a rate of 1.84 per cent.

Age Incidence and Mortality—Of more significance is the study of the relationship of age incidence to mortality. Here, too, our findings are in accord with those of other investigators. The frequently repeated statement that the mortality rate of acute appendicitis is greatest at the extremes of life is well corroborated by our statistics. Table III clearly illustrates this. Thus, in the first decade of life, there were 1,610 cases operated upon, with 44 fatalities, a death rate of 2.73 per cent. This is three times as high as the rate in the next succeeding decade, where our largest group of cases, according to age, occurred. Of course, a death rate of 2.73 per cent may not seem unduly high. However, in a subsequent report, where we intend to study this problem more thoroughly in children below the age of five, we know definitely that the toll is higher. Briefly, this is due to the difficulties of establishing an early diagnosis in the very young, as well as the more rapid progression of the pathologic process, the vulnerability of the peritoneum to infection, and the lack of omental protection. Acute appendicitis is essentially an illness of adolescence and early adult life. Between the ages of 11 and 40, there were a total of 6,128 in our series of 8,727, about 70 per cent of all studied.

TABLE III
AGE INCIDENCE IN RELATION TO MORTALITY RATE

Age	Cases	Deaths	Mortality Rate
To 11	1,610	44	2.73%
11-20	2,822	24	0.85
21-30	2,182	23	1.05
31-40	1,134	28	2.47
41-50	564	37	6.56
51-60	266	13	4.88
61-70	114	19	16.66

It is interesting to note that the death rate was lowest during the second decade, slightly higher in the third decade, definitely mounting in the fourth and then jumping rather rapidly to a figure of 6.5 per cent in the fifth decade. Between the ages of 51 to 60, the rise was not appreciable. However, beyond age 60, the figure assumes formidable proportions. Here the toll is at its greatest, 16.66 per cent. The difficulty does not lie in making the diagnosis. Age brings with it the complications of degenerative processes, and metabolic disorders, so that the human organism is less able to cope with acute infectious

processes. Thus, in reviewing our mortalities, we shall find later that a goodly number of our aged individuals succumbed because of impaired cardiovascular systems, and metabolic diseases, as well as from peritonitis.

Duration of Illness and Mortality—Undoubtedly, the most important single factor in lowering the mortality of acute appendicitis is the rapidity with which surgical intervention is undertaken. McBurney, Murphy, Deaver and many others have emphasized and reiterated this fact. As long as the infectious process remains localized to the appendix, the mortality rate will be kept at an irreducible minimum. Once the pathologic process extends beyond the confines of the organ to involve the peritoneum, complications, with an attendant rise in morbidity and mortality, ensue. To prevent this, it is necessary to operate as early as possible. As a rule, during the first 24 hours, the inflammation remains localized to the appendix. While we encountered several cases where perforation had occurred within the 12-hour period after the onset of symptoms, their paucity was such as to strikingly emphasize the generalization just made.

TABLE IV
MORTALITY IN RELATION TO DURATION OF ILLNESS

Days Ill Before Operation	Cases	Deaths	Mortality Rate
First 24 hrs	2,850	17	0.59%
1-2 days	2,424	35	1.44
2-3 days	1,435	32	2.23
3-4 days	742	33	4.44
4-5 days	384	25	6.51
5-6 days	190	10	5.26
Over 6 days	645	33	5.11
Unknown	57	3	5.26
Comparative mortality, first 3 days			
First 24 hrs	2,850	17	0.59
First 48 hrs	5,274	52	0.98
First 72 hrs	6,709	84	1.24

In our series, 2,850 cases were operated upon within 24 hours after the onset of symptoms. These represented, roughly, about one-third of our series. Seventeen in this early group died, a mortality rate of 0.59 per cent. In other words, the average chance of recovering from acute appendicitis, when subjected to surgery within 24 hours of the onset, was 198.8 out of 200 cases, which probably represents an irreducible minimum. In the second 24 hours of illness, 2,424 cases were operated upon, 35 succumbed and the mortality rate rose to 1.44 per cent—almost three times as high as during the first 24 hours. With each succeeding day of delay, the appended Table IV graphically depicts a rise in the death rate. Five thousand, two hundred seventy-four cases were operated upon within 48 hours, with a creditable recovery record of 99.02 per cent. Of patients operated upon during the third day of illness, we had 1,435, with 32 failing to survive, showing a mortality rate

almost four times as high as that encountered in the first group of cases. Thus, over three-quarters of our cases were subjected to operation within 72 hours of onset, with a mortality rate of 1.24 per cent. After the third day, the death rate climbed rapidly to 4.4 per cent between the seventy-second and ninety-sixth hours, and to 6.5 per cent from the fourth to fifth days. Fortunately, less than one-quarter of our cases came to operation after the third day, and this fact unquestionably contributed to our low death rate. After the fifth day of illness, operation yielded recoveries in somewhat less than 95 per cent of the cases.

There are some who advocate the postponement of operation after acute appendicitis has existed for over 72 hours. While there may be some merit in this practice, such has not been our procedure. As soon as the diagnosis was made and the patient hospitalized, surgical intervention was instituted. Each case has to be evaluated individually, and not treated by any rule of thumb. Many of our cases operated upon after the third day still showed a lesion confined close to, if not solely to, the appendix. There were, it is true, a number of patients in a moribund state, who were subjected to surgery. This constituted poor judgment and increased our mortality rate. On the whole, however, we believe excellent judgment was displayed as to the proper time to operate. In closing the discussion of this particular aspect of the problem, let us reemphasize: Operate within 24 hours of the onset of symptoms, and, other things being equal, the deaths in acute appendicitis will be reduced to the lowest figure humanly possible.

Temperature Reaction—A rather detailed study was made of the temperature reaction to acute appendiceal inflammation. Referring to Table V, we observe that the majority of cases did not have an elevation of temperature above 102° F. As a matter of fact, 6,790 cases, or over 75 per cent of our total, showed a febrile reaction below 102° F. In less than 25 per cent of the cases was there a temperature range from 102° to 105° F.

TABLE V
TEMPERATURE REACTIONS

Degrees Fahr	No of Cases	Percentage of Total
Under 100	1,831	20.97
100-101	2,794	32.11
101-102	2,165	24.80
102-103	1,203	13.78
103-104	534	6.11
104-105	158	1.81
Over 105	38	0.41
Unknown	4	0.01

The majority of the cases showing a low febrile movement fell into the group of uncomplicated cases, *i e*, without peritoneal reaction or involvement. Those cases with fever above 102° F, generally speaking, were complicated by some degree of peritonitis.

Our impressions from the study of this aspect of the disease is that acute appendicitis *per se* is attended with only a moderate febrile reaction, and the presence or absence of fever is of limited aid in the differential diagnosis. We have observed many cases of acute gangrenous inflammation of the appendix with temperatures ranging below 100° F. So that, in the presence of other signs pointing to a diagnosis of acute appendicitis, a normal or slightly elevated temperature should not be permitted to sway one away from the opinion entertained.

TABLE VI
RELATION OF TEMPERATURE TO DURATION OF ILLNESS

Temperature	1 Day	2 Days	3 Days	4 Days	5 Days	6 Days	Over 7 Days
Under 100	842	417	218	103	62	22	153
100-101	1,431	568	298	146	77	42	169
101-102	1,042	564	263	103	60	31	115
102-103	471	375	162	77	31	17	70
103-104	178	160	86	32	17	9	45
104-105	40	55	25	8	11	7	11
Over 105	12	13	2	5	2	2	2

Table VI shows the variations of the temperature reactions according to the duration of the illness. This, too, seems to corroborate the fact that during the first 48 hours, when the greatest number of uncomplicated cases were seen, there also occurred the greatest number of cases with low febrile reaction.

Pulse Rate—Brief mention may be made relative to the pulse rate in acute appendicitis (Table VII). The pulse rate on admission was noted in our analysis in every case (except in a few infants, where the pulse rate was not recorded).

We may infer that in a good majority of cases, acute appendicitis is accompanied by a definite elevation in the pulse rate (70 per cent), occurring somewhere between 91 and 120 plus.

TABLE VII
ANALYSIS OF PULSE RATE

Pulse	No of Cases	Percentage of Total
Under 70	110	1.25
70-80	755	8.64
81-90	1,579	18.08
91-100	2,289	26.22
101-110	1,289	14.76
111-120	1,633	18.70
Over 120	1,052	12.35

Blood Reaction—The response of the leukocytes to acute inflammation of the appendix was studied in searching detail. We attempted to establish the relationship, if any, between leukocytic reaction and the elevation in temperature. Our investigation served to show no correlation in this respect. Pro-

portionately, there were just as many instances with high leukocyte counts where the temperature range was 100° F or below, as there were when the febrile response was 103° F and over. The extremes of blood counts varied from 8,000 W B C, with 70 per cent polymorphonuclear leukocytes, to 39,000 W B C, with 95 per cent polymorphonuclear leukocytes. In general, our studies showed that acute appendicitis was attended with a leukocytosis averaging between 12,000 and 18,000, and a polymorphonuclear count between 75 and 90 per cent.

Incidence of Previous Attacks—A study was made of those cases of acute appendicitis that had had previous acute attacks. Referring to Table VIII, one notes some interesting data.

TABLE VIII
ANALYSIS OF INCIDENCE OF PREVIOUS ATTACKS

No of Cases	Pathologic Process	First Day	Sec- ond Day	Third Day	Fourth Day	Fifth Day	Sixth Day	Seventh Day
805	Acute catarrhal	318	204	98	46	34	17	88
862	Acute suppurative	476	189	79	46	22	7	43
556	Acute gangrenous	395	159	50	18	6	1	17
335	Acute perforative	144	115	50	8	3	6	9
127	Abscess	19	25	29	10	8	3	33
2,685	Totals	1,262	692	306	128	73	34	190

In all, there were 2,685 cases operated upon that had had one or more previous attacks, about 30 per cent of the total. Of these, we find that in the first decade studied, 1,465 cases out of a total of 4,132, or 35 per cent, had had previous attacks. In the second decade, out of a total of 4,595 cases coming to operation, only 1,220 cases, or 26 per cent, had been previously ill with appendicitis. Thus, in one decade, there was a reduction by 25 per cent of patients who had had previous attacks. We believe this to be quite significant. To us, it indicates that both physicians and patients have become more "appendicitis conscious" and are less willing to temporize with this condition. To further substantiate this contention, we find that 1,262, or roughly 50 per cent, of patients who had had previous attacks were operated upon during the first 24 hours of the present illness. This percentage excels by far the figure of 32 per cent previously reported, of the 2,850 cases in our total series, that came to operation during the first 24 hours of illness.

In reviewing the statistics in Table VIII, we feel that the occurrence of previous attacks does not seem to appreciably influence the relationship existing between the pathology encountered and the duration of the present attack.

Anesthesia—Until 1927, inhalation anesthesia, ether alone, nitrous oxide and ether, or nitrous oxide augmented by local novocain infiltration, was employed almost exclusively. A very small number of operations were performed under local anesthesia alone. In 1927, spinal anesthesia was introduced into our institution, and 36 appendicectomies were performed for acute

appendicitis under this anesthetic. From then on, all have favored the use of spinal over inhalation anesthesia. Not only have we obtained better relaxation, but we have definitely secured a lowering of postoperative complications due to the anesthetic *per se*. Another point of importance is, that with spinal anesthesia, we have been able to avoid the "pumping action" of the abdomen incident to induction with a general anesthetic and its harmful effect on peritoneal inflammation.

Six thousand, six hundred forty-one cases were operated upon under general inhalation anesthesia, with 90 instances of postoperative respiratory complications, an incidence of 1.35 per cent. Of 1,990 appendicectomies, performed under spinal anesthesia, only two patients developed respiratory morbidities (0.1 per cent). In 96 cases, local anesthesia was employed, and in one patient a postoperative respiratory complication arose. Thus in our series, spinal anesthesia proved to be the most favorable.

Pathology and Mortality—Again, let us reiterate that gross statistical figures carry no weight and teach nothing. Analyzing these mortality rates, in terms of pathologic entities, during the 20-year period under consideration, shows that 1,754 cases were diagnosed, pathologically, as acute catarrhal appendicitis. Four of these patients died, a rate of 0.22 per cent, 2,771 were of the acute suppurative type—of these eight died, a mortality rate of 0.28 per cent. During that same period, 1,939 cases of acute gangrenous appendicitis were encountered, with 20 deaths—a rate of 1.03 per cent. In other words, appendicectomy was performed in 6,464 cases of nonperforated appendicitis with but 32 deaths, 0.50 per cent, or less than one death in 200 cases, and that where 4,270 cases were acutely suppurative or acute gangrenous (Table IX). If such a record resulted in our perforated variety of appendicitis, then, and only then, could we rest as having solved our problem of acute appendicitis with dispatch. Unfortunately, this is not the case.

TABLE IX
MORTALITY RATE IN CASES OF NONPERFORATED APPENDICITIS

Type of Pathology	Procedure	No of Cases	Deaths	Mortality Rate	
Acute catarrhal	Stump inversion	1,753	4	0.22%	} 0.22%
Acute catarrhal	Without stump inversion	1	0	0.00	
Acute suppurative	Stump inversion	2,754	8	0.28	} 0.28%
Acute suppurative	Without stump inversion	17	0	0.00	
Acute gangrenous	Stump inversion	1,906	18	0.94	} 1.05%
Acute gangrenous	Without stump inversion	33	2	6.06	

In explanation of Table IX. It has been our practice to invert appendicular stumps in performing appendicectomy, and where such had not been carried out, there must have been entailed, such pathologic involvement of the cecum as to forbid stump inversion. However, since no peritoneal involvement of the acute process presented itself, the cases must still be considered, and rightly so, as nonperforated.

TABLE X

MORTALITY RATE IN CASES OF PERFORATED APPENDICITIS

Type of Pathology	Procedure	No of Cases	Deaths	Mortality Rate	
Perforated appendicitis	With stump inversion	964	15	1 55%	} 1 56%
	Without stump inversion	60	1	1 66	
Abscess	With stump inversion	419	24	5 72	} 6 02%
	Without stump inversion	100	10	10 00	
	Without appendicectomy	144	6	4 17	
Local peritonitis	With stump inversion	303	16	5 28	} 6 54%
	Without stump inversion	30	6	20 00	
	Without appendicectomy	3	0	0 00	
Diffuse peritonitis	With stump inversion	172	41	23 80	} 32 50%
	Without stump inversion	41	17	41 50	
	Without appendicectomy	27	20	74 00	

The results of our perforated cases (Table X), leave much to be desired, in spite of the fact that they compare favorably with many, if not all, of the better clinics. Those perforated cases, that presented little or no macroscopic peritoneal involvement, were 1,024 in number, with 16 deaths, a rate of 1 56 per cent. Even this record could be well tolerated, but, when we begin to examine our results with local peritonitis, abscess formation and diffuse peritonitis, there can be no doubt but that there is room for improvement. As could be well expected, the results with local peritoneal involvement and those with abscess formation present practically identical figures, namely, 663 cases of acute appendicitis with resultant perforation and abscess formation yielded 40 deaths, a 6 03 per cent mortality rate, whereas 336 perforated appendices with local peritoneal inflammation resulted in 22 deaths, or 6 54 per cent. Therefore, it can be understood why both these entities should be considered under one category. If this group is so considered, 999 cases were encountered with 62 deaths, a rate of 6 2 per cent. The deaths in this group should be instructive, and in our analysis of those who succumbed, we hope much may be elucidated.

Perforated appendicitis with diffuse peritonitis is a blot that must be eradicated. So long as the medical profession allows the appendiceal perforation to spread its infective material throughout the peritoneal cavity, just so long will the death rate of appendicitis remain where it is. There can be no excuse for a diffuse peritonitis in acute appendicitis. Perforations may occur, but certainly there can be no justification for allowing the peritoneum to be virtually inundated with the infection. Perforations may occur early, probably too soon for the physician to help, but, certainly, proper care can prevent transforming a local peritonitis into a diffuse one.

Patients must be taught the danger of using cathartics to relieve abdominal pain. Physicians, too, must be impressed with the realization that there can be no condonation for effecting a bowel evacuation that results in diffuse peritonitis. There can be no midway course, when the diagnosis of

acute appendicitis is even suspected. Either we treat the patient as a potential peritonitis case or operate at once. There can be no defense for any *modus operandi* that stimulates peristalsis. One might as well knead the intestinal tract with the offending organisms, and see to it that no serosal surface remains uncontaminated. No patient, suspected of acute appendicitis, should be allowed to remain at home. If observation must be resorted to, the hospital offers better facilities for such observations.

These patients, when catastrophic results ensue, are certainly more advantageously treated, if not subjected to transportation in the presence of local peritonitis. Fluids are more easily administered parenterally in an institution where such procedures are routinely performed. Expert observation certainly transcends familial hysterical kindness. To us, there can be no doubt that these patients belong in hospitals, and the sooner we can educate our clientele to that fact, the sooner may we obtain better results. There can be no doubt that if we must err, let us err on the side of hospitalizing too often, rather than too late.

Of our 240 cases with diffuse peritonitis, 77 died, one case in three. Almost unbelievable!—and this 50 years after Reginald Fitz wrote on perforating inflammation of the vermiform appendix. None of these cases was in the hospital to be observed. All were operated upon soon after admission. The value of such therapy will be discussed later, but one incriminating feature is the fact that these patients, at this day and age, had allowed themselves or had been allowed, by those who should have known better, to reach such a state of peritoneal infection.

Should this communication bring home but this one point, it shall not have been in vain. Let the family know that you suspect appendicitis. Let them realize late transportation is dangerous. Let us teach the doctrine of early hospitalization in suspected cases of appendicitis. Let us treat suspected cases as they should be treated. Let us come to the realization that no one can predict the ultimate outcome of any acute appendicitis suspect. Let us rather err in too early operation than in one too late.

Operative Technique—Much has been written favoring each incision employed in operations for acute appendicitis. Before stating our views on this important problem, may we say that each surgeon must decide for himself the procedure in which he is most adept and most familiar. There can be no doubt that in some hands one method may be as good as another. On the other hand, what seems simple and facile to some, may be quite difficult to others. Each surgeon, therefore, must decide on the *modus operandi* best suited to him.

Incision—At this hospital, the McBurney approach was employed in over 99 per cent of cases of acute appendicitis. Reiteration as to the advantages of this incision over all others, should reveal again the superiority of this approach. Postoperative herniation, even though drainage be resorted to, is minimized. To us, the foremost argument in favor of the gridiron incision is that all manipulation during the operation is effected outside or lateral to

the general peritoneal cavity. This incision affords the surgeon direct approach upon the offending lesion.

The general peritoneal cavity need never be contaminated. One or two sponges applied to the medial aspect of the wound allows for complete exposure and extirpation of the appendix without spreading the infection to the coils of the small intestine—an unfortunate, too frequent concomitant of the right rectus approach.

At all times, manipulation is accomplished in the infected area. No spread of the infection ensues, no matter how extensive the pathologic process encountered. True, at first, there may be difficulty in determining, from one's finger tips, the extent of the inflammation, but just as a master violinist has eyes at his fingers' ends, so too, can the surgeon develop the finesse of tactile acuity that leads one to entertain the thought that surgery is an art as well as a science.

Truly remarkable is the mild postoperative reaction that follows an appendectomy through a McBurney incision, and that, notwithstanding the severe lesions encountered. Not only is the postoperative convalescence smoother, but also shorter.

Wherever open treatment is indicated, no incision can compare with this invaluable approach, for the abdominal wall almost closes upon itself, as it were, without any sutures.

Too frequently, is the argument propounded that wherever an error in diagnosis be made, the surgeon is handicapped, as well as the patient, in attempting an operation other than appendectomy through this right McBurney incision. Such was never the contention of McBurney, nor can anyone justify attempting any operation through an improperly placed incision.

There is no reason to prevent any surgeon from closing any improperly placed incision and altering his approach through another, more judiciously placed. No one can justify removing a left ovarian cyst through a right McBurney incision, especially if to the detriment of the patient. To us, the right guidance incision is indicated only in acute appendicitis, and should never be employed whenever complete exploration is indicated. Adequate exposure is not a virtue of the McBurney incision.

Stump Inversion—Stump inversion, too, has its many proponents. Many surgeons advocate simple section of the appendicular stump with cauterization or carbolization. We believe such a procedure unphysiologic, since it seems unnatural to allow mucosa to come into contact with serosa. There is no doubt but that such treatment of the stump must carry with it the probability of the formation of more adhesive bands than does the method of tucking in the stump, which results in the apposition of serosal surfaces. Not very long ago, much was written about stump inversion versus stump burial. To us, who have seen thousands of stump inversions following ligation of the stump, the danger of cecal wall abscess is more mythical than real. We have not found ligation of the appendicular stump with inversion, or as some name it, stump burial, an unsafe procedure. However, the added safety, that

stump ligation carries with it a hemostatic adjuvant, cannot be denied. Bleeding into the alimentary canal, a complication almost impossible with stump ligation, is extremely difficult to correct. However, it may be added, that never is stump inversion considered where cecal wall damage has been such as to interdict such practice.

Drainage—The problem of drainage in acute appendicitis still leaves much to be desired. The old adage of "drain when in doubt" has now swung to "don't drain when in doubt." If one remembers that the general peritoneal cavity cannot be drained, if one is clear that the only purpose of drainage is to allow discharge of pus, and that a drain site is an advantageous guide for the egress of any fecal material that may ensue following damage to the cecum, indications for drainage become apparent.

Every abscess requires drainage, every retroperitoneal appendix should be drained if there is any contamination, every case where the integrity of the cecal wall may be in doubt, every peritonitis where frank pus is expected to ensue, every technically difficult appendectomy should be drained, if there has been any possible soiling.

Gangrenous appendicitis with clear or turbid nonodorous fluid does not require drainage, nor does a plastic exudate covering the appendix necessitate a drain. However, we cannot agree with those who believe that diffuse peritonitis cases should be closed tightly.

The discussion over the material employed for drains is more academic than practical. We have been using Penrose drain either alone or with gauze. We realize that soft rubber tubing in some hands has acted favorably. The matter of drain removal resolves itself into how long does a drain act as a drain and when does it become a foreign plug? There is no doubt but that 10 days should suffice for the formation of a tract. Too often have we seen a drain removed too late, only to watch ounces of pus follow in the wake of the drain. Too clearly has this demonstrated that drains may block as well as drain a cavity.

Complications—Complications in acute appendicitis may be classified into two categories, those secondary to the disease entity, and those resultant from the surgeon's intervention.

Acute appendicitis, if allowed to progress unhampered by human intervention, may subside. We fully realize the danger that such a statement may carry to the inexperienced physician, but the fact still remains, and in all fairness should be stated, that there can be no doubt that rare cases of acute appendicitis resolve, some completely, and others pass on into a pathologic *residua* of chronicity. For we know, there are exceptional cases of acute appendicitis where operation, though advised, had been deferred, and yet the patient survived, but those of us who have seen acute appendicitis in its protean manifestations and its chameleon-like diversifications can take but one attitude, and only one, and that is to excise the offending organ. All the more is this true when we realize that no one can even conjecture which

appendix may burst and which may resolve. Certainly, no one can justify a guess where a human life is at stake.

Acute appendicitis, in the vast majority of instances, if unattended, is more likely to progress in its severity. Suppuration may terminate in necrosis, and gangrene may lead to perforation, which must contaminate the peritoneum, the results of the treatment of which is problematical.

Perforation may result in a localized involvement of the peritoneal cavity or it may be diffuse in its spread. Diffuse peritonitis may also eventually localize in any part of the peritoneal cavity, be it pelvic, subhepatic or subphrenic.

Spread of the infection may not be limited to the peritoneal cavity, for the lymphatic extension into the pleural cage too frequently ensues.

Appendiceal infection may spread not only by contiguity and by lymphatic extension, but frequently also by way of the circulation. Thrombophlebitis of the appendiceal vessels, as a precursor of pyelophlebitis, is well understood. From these beginnings, the organism may then be transplanted through the systemic circulation with all the possibilities that a bacteremia may create.

In addition to this group of complications inherent in appendicitis, there are those sequelae that a surgeon may implant. To be sure, at times, in spite of surgical intervention, complications may ensue as though no therapeusis at all were undertaken. However, such sequelae as hemorrhage, fecal fistulae, herniation, evisceration and many other misfortunes, secondary to human endeavors, require careful consideration. It is our purpose to analyze each of our complications in another communication.

Length of Hospitalization—Of the 8,539 cases surviving, 4,830 were not drained, and 3,699 were drained. All these cases were studied from the viewpoint of the length of hospitalization (Table XI).

TABLE XI

ANALYSIS OF TIME OF HOSPITALIZATION

No. of Days in Hosp.	Drained	Not Drained
Less than 10 days	153	1,174
10-14 days	1,562	3,193
15-19 days	1,003	329
20-24 days	462	84
25-29 days	241	38
30-34 days	102	13
35 days and over	176	9

Because those cases drained represented complicated or potentially complicated acute appendicitis, over 50 per cent had a period of hospitalization exceeding 15 days, whereas 90 per cent of the undrained cases left the hospital within 14 days after admission.

Mortality—As previously mentioned, there were 188 deaths in the series. Inasmuch as we intend to deal with these in detail in a subsequent communication, we will but briefly comment on the cause of death. One hundred thirty-one, or 69 per cent of deaths, were due to peritonitis, 11 died

from pulmonary complications, seven deaths were caused by cardiac and cardiovascular complications, 17 deaths were due to embolism, and 22 cases died, because of a variety of causes, which we have grouped as miscellaneous

SUMMARY

A survey of 8,727 cases of acute appendicitis is presented, with especial reference to mortality rate, age incidence and time element

The value of early operation is statistically proven by the remarkably low mortality rate in early cases

The severity of the pathologic process determines the operative procedure, and the degree of peritoneal involvement the difference between low and high mortality results

The value of the McBurney approach is stressed, and such technical desiderata as stump inversion and drainage are discussed

Finally, complications are merely classified, with detailed analysis to be carried out in another communication

These cases comprise all operations for acute appendicitis—private and ward—operated upon by Attending and House Staffs. We wish to thank all those surgeons who have permitted us to include their cases in this report

REFERENCES

- ¹ Krech. N. Y. State Jour. Med., 35, 248, 1935
- ² Seifert. Deutsch. Ztschr. f. Chir., 244, 176, 1934
- ³ Swain. Arch. Surg., 28, 782, 1934
- ⁴ Wevill and Wallace. Edinburgh Med. Jour., 41, 557, 1934
- ⁵ Muller. Hospitalstid., 77, No. 30, 34, 1934
- ⁶ Donaldson. Penna. Med. Jour., 38, 73, 1934
- ⁷ McKenna. ANNALS OF SURGERY, 104, 617, 1936
- ⁸ Young. Southern Surg., 6, 131, 1937
- ⁹ Stanton. Surg., Obstet., and Gynec., 59, 738, 1934
- ¹⁰ Jensenius. Ugeskr. f. Laeger, 98, 1085, 1936
- ¹¹ Rhodes. Calif. and Western Med., 45, 458, 1936
- ¹² Lazzarini. Riforma Med., 53, 123, 1937
- ¹³ Davis. J. A. M. A., 108, 1498, 1937
- ¹⁴ Guerry. J. A. M. A., 107, 1910, 1936
- ¹⁵ Reid. J. A. M. A., 106, 665, 1936
- ¹⁶ Holden and Wells. Surg., Obstet., and Gynec., 64, 239, 1937
- ¹⁷ Sperling and Myrick. Surg., 1, 255, 1937
- ¹⁸ Ray. N. Y. State Jour. Med., 38, 412, 1938
- ¹⁹ Poole. Am. Jour. Surg., 32, 469, 1936
- ²⁰ Allen. J. A. M. A., 109, 121, 1937
- ²¹ Habler. ANNALS OF SURGERY, 103, 86, 1936
- ²² Angel. South. Med. and Surg., 98, 426, 1936
- ²³ Sprague. Surg., Gynec., and Obstet., 66, 166, 1938

STUDIES OF LIVER FUNCTION BY MEANS OF QUICK'S HIPPURIC ACID TEST¹

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DELPRAT AND WHIPPLE,¹ in 1912, were the first to suggest that the determination of hippuric acid excreted after the administration of benzoate might be used as a test for liver function. They did their work on dogs, and advanced their suggestion unaware of the fact that in the dog liver benzoic acid is synthesized in the main to benzoyl-glycuronic acid and not to hippuric acid,² as in the case in the human liver. In 1933, Quick³ introduced his hippuric acid test for liver function in man, and described a simple analytic method for the estimation of hippuric acid in urine, which made the test available for clinical diagnostic purposes. Weichselbaum and Probststein⁴ recently modified Quick's method, improving the accuracy of the procedure without impairing its simplicity. By means of the improved method it was ascertained that Quick's statistics represent only partial recovery of the hippuric acid from the urine. It was shown, furthermore, that the losses from solubility of hippuric acid in urine are too variable to give much meaning to Quick's correction for the solubility. In view of this, we deemed it necessary to revise the range of normal values in order to have an adequate basis for comparison when applying the test to patients.

I STUDIES ON NORMAL SUBJECTS

Our normal subjects were healthy adults, mainly members of the hospital staff. In the first group of 14 subjects (nine males and five females), 6 Gm of sodium benzoate were administered as suggested by Quick and, except for the modification in the analytic technic, Quick's procedure was followed in every detail. The findings on this group are shown in Table I.† As may be seen, our subjects eliminated in four hours from 62 to 87 per cent of the ingested sodium benzoate, as compared with 47 to 76 per cent found by Quick⁵ in a group of patients who had no clinical evidence of hepatic damage. The average excretion in our group was 73 as against 60 per cent as reported by Quick, or expressed in terms of benzoic acid, healthy individuals excrete in four hours, on an average, 3.7 Gm of the 6 Gm ingested, while Quick found an average value of 3 Gm. This substantial difference may be entirely attributed to the improvement upon Quick's method by Weichselbaum and

* Aided by the Louis M. Monheimer Research Fund. Submitted for publication May 8, 1939.

† In this table, as well as throughout the paper, the corrected hippuric acid is calculated as its sodium benzoate equivalent, in order to facilitate the calculation of the amount excreted as the percentage of the amount ingested.

Probstein However, this difference may to some extent be due to the difference in the selection of subjects for obtaining normal values We used healthy adult subjects, while Quick used patients without suspected disease of the liver

TABLE I

EXCRETION OF HIPPURIC ACID BY NORMAL SUBJECTS, OVER A FOUR-HOUR PERIOD AFTER THE INGESTION OF 6 GM OF SODIUM BENZOATE

Subject	Age	Sex	Urine Volume Cc	Hippuric Acid Computed as Na-Benzotate	
				Amount in Urine, Gm	Per Cent of the Na-Benzotate Ingested
S L	33	M	432	5.02	84
T W	30	M	354	4.65	77
W R	21	M	229	4.56	76
D B	30	M	217	4.88	81
R J	26	M	265	4.77	79
D P	26	M	257	4.98	83
R C	24	M	668	5.23	87
H G	21	M	253	4.95	83
M S	53	M	688	4.63	77
H K	30	F	760	4.00	67
A T	23	F	218	4.52	75
A H	18	F	233	3.83	64
C S	26	F	319	3.72	62
M H	22	F	226	3.85	64

It is noteworthy that none of the female subjects eliminated as much as the lowest quantity eliminated by any of the males, the figures being 62 to 75 per cent for the females, and 76 to 87 per cent for the males In view of the small number of subjects studied, however, we refrain from drawing any conclusions from these figures

Examining the volume of urine voided during the test, we can find no relationship between the urinary volume and the amount of the hippuric acid excreted Thus, subject S L excreted 5.02 Gm in 432 cc, and subject D P eliminated 4.98 Gm in 257 cc, while subject H K, with the largest volume of urine, 760 cc, eliminated only 4 Gm However, it should be borne in mind that Snapper and Grunbaum⁶ observed that patients with nephritis associated with retention of urea may eliminate more hippuric acid in large volumes than in small volumes of urine

Most of our subjects complained of considerable gastric discomfort, and not a few vomited after taking 6 Gm of sodium benzoate Quick⁵ suggested the use of smaller quantities whenever the 6 Gm dose causes vomiting We regarded it desirable to examine the possibility of using smaller quantities of benzoate as the general standard dose

Accordingly, we performed the test with 4 Gm doses on 24, and with 3 Gm doses on 23 normal subjects The procedure was otherwise the same as with the 6 Gm dose, the hourly elimination of hippuric acid being determined for four hours We found that either of the two smaller doses was

much better tolerated than the 6 Gm dose. To further determine the possibility of using either of the smaller doses, it became necessary to analyze our results in order to learn whether or not the smaller doses are capable of taxing the ability of the liver to synthesize hippuric acid at the same maximum rate at any single hour in the course of the observation as the 6 Gm dose. To this end, we determined the hourly excretion of hippuric acid on seven of our subjects after the ingestion of the three different doses. It was found that the maximum excretion was, without exception, attained in the second hour after the 4 Gm, and in either the second or third hour after the 6 Gm dose. In Table II these maximum excretions for one hour are compared for the seven subjects.

TABLE II

MAXIMUM HOURLY EXCRETION OF HIPPURIC ACID AFTER
INGESTION OF VARIABLE AMOUNTS OF SODIUM BENZOATE

Subject	Maximum Hourly Excretion of Hippuric Acid After Ingestion of		
	6 Gm	4 Gm	3 Gm
S L	1 40	1 37	1 27
W R	1 34	1 34	1 21
H G	1 71	1 40	1 27
T W	1 38	1 35	1 14
M S	1 40	1 41	1 11
R P	1 49	1 51	1 25
M H	1 12	1 36	1 09
Average	1 40	1 39	1 19

It may be seen that the maximum hourly rate was the same after the 6 and 4 Gm doses, whereas the 3 Gm dose was not sufficient to call forth a similar maximum response. This finding indicates that the maximum hourly excretions obtained after the 4 and the 6 Gm doses represent the maximum hourly rate of hippuric acid synthesis in the liver under the given standard conditions. Raising the dose above 4 Gm does not lead to an increase of this maximum hourly rate, although the total excretion for four hours may be augmented. We have even a few cases in which the highest excretion during any single hour is less with the 6 than with the 4 Gm dose.

TABLE III

COMPARISON OF OPTIMUM HOURLY EXCRETION OF HIPPURIC ACID IN DIFFERENT
SUBJECTS FOLLOWING INGESTION OF VARIABLE AMOUNTS OF SODIUM BENZOATE

	Optimum Hourly Rate of Hippuric Acid Excretion After Ingestion of		
	6 Gm (13 Subjects)	4 Gm (24 Subjects)	3 Gm (23 Subjects)
Lowest	1 04	1 06	0 98
Highest	1 92	1 80	1 41
Average	1 38	1 39	1 19

In Table III the extreme and average values of the maximum hourly excretions in all the subjects studied are recorded in groups arranged according

to the dose of benzoate ingested. Here it is demonstrated on a large number of subjects that the range of variation as well as the average values in regard to the maximum hourly rate are essentially the same for the 6 and the 4 Gm doses. The average for 6 Gm is 1.38 and that for 4 Gm is 1.39. The 3 Gm dose falls short of eliciting a similar response, evidently because at no time does it furnish to the liver a concentration of benzoic acid that would suffice for the possible maximum velocity in the synthetic reaction. On the ground of the foregoing, it can be stated that the 4 Gm dose is large enough to give the liver an opportunity to synthesize hippuric acid at its maximum capacity during one hour. In healthy individuals a maximum of from 1.38 to 1.92 Gm of sodium benzoate can be synthesized to hippuric acid in the course of one hour. This maximum cannot be raised by increasing the dose above 4 Gm.

TABLE IV

RATE OF EXCRETION OF HIPPURIC ACID IN NORMAL SUBJECTS AFTER INGESTION OF 4 GM OF SODIUM BENZOATE

Subject	Age	Sex	Per Cent Excreted During				Total in Four Hours
			First Hour	Second Hour	Third Hour	Fourth Hour	
1 L	33	M	28	34	25	7	94
2 W R	21	M	23	33	25	10	91
3 P	21	M	38	31	12	4	85
4 S	22	M	23	31	24	9	87
5 B	30	M	19	45	19	3	86
6 G	21	M	28	35	17	4	84
7 C	21	M	28	37	18	4	87
8 W	30	M	25	34	28	5	92
9 M S	53	M	27	35	21	9	92
10 S 2	19	M	21	31	30	9	91
11 A	24	M	28	37	19	5	89
12 R	28	M	32	36	19	4	91
13 H	32	M	21	31	28	6	86
14 M H	18	F	28	37	19	3	87
15 Z	29	F	21	29	27	12	89
16 M L H	22	F	18	34	23	5	80
17 M K	32	F	29	33	23	8	93
18 R L	28	F	23	30	27	8	88
19 P 2	40	F	26	48	13	3	90
20 K	35	F	36	41		20*	97
21 S 3	25	F	26	35	21	7	89
22 T	24	F	22	33	24	6	85
23 C	27	F	14	41	29	2	86
24 T 2	26	F	24	26	22	11	83
Lowest			14	26	12	3	80
Highest			38	48	30	12	97
Average			25	35	22	6	88

* Combined excretion for third and fourth hours

We conclude then that 4 Gm of sodium benzoate is the ideal dose to be used for the Quick test. Because of this, we give in Table IV in some detail our findings in 24 normal subjects (13 males and 11 females) who have taken this dose. The total excretion of hippuric acid (computed as sodium benzoate) for four hours ranges from 80 to 97 per cent of the ingested sodium benzoate, with an average of 88 per cent. There is no appreciable difference between the sexes. The curve of the hourly rate of excretion for the four-hour period is of a uniform character for all the subjects. Thus in all but one instance, the highest level of hippuric acid elimination was observed in the second hour, 50 to 77 per cent of the ingested sodium benzoate was handled during the first two hours, while the level of excretion during the third and fourth hours depended upon the quantity of the hippuric acid that had been eliminated in the preceding periods, in that the excretion in the last two hours tended to be the higher, the lower the excretion in the first two hours had been.

Since 4 Gm of sodium benzoate is the smallest dose administered by mouth that is capable of showing the maximum rate at which the liver is able to synthesize hippuric acid, in those instances in which the 4 Gm is followed by vomiting, the sodium benzoate must be administered intravenously, as recently suggested by Quick, Ottenstein and Weltcheck.⁷

TABLE V

EFFECT OF ADMINISTRATION OF SODIUM BENZOATE PLUS GLYCINE TO NORMAL SUBJECTS ON THE EXCRETION OF HIPPURIC ACID

Subject	Excretion of Hippuric Acid (in Terms of Na-Benzoyate)			
	4 Gm of Na-Benzoyate'		4 Gm of Na-Benzoyate + 5 Gm of Glycine	
	Grams	Per Cent of Ingested Benzoyate	Grams	Per Cent of Ingested Benzoyate
1	1.08	27	2.05	51
2	0.94	23	1.65	41
3	1.05	26	2.02	50
4	1.13	28	2.13	53
5	1.01	25	2.09	52
Average	1.04	26	1.98	49

Quick⁸ made the observation that the fundamental factor governing the rate of synthesis (and subsequent excretion) of hippuric acid is the rate at which the liver is able to furnish glycine. Thus by administering glycine simultaneously with benzoate, the rate of elimination of hippuric acid can be increased. We have repeated this experiment by administering 5 Gm of glycine with 4 Gm of sodium benzoate to five subjects. Our findings, recorded in Table V, confirm Quick's observation. It may be seen that the excretion of hippuric acid during the first hour was practically doubled when 5 Gm of glycine was administered together with the sodium benzoate.

In another experiment, by administering increasing quantities of glycine with 6 Gm of sodium benzoate to two normal subjects, we attempted to determine the maximum ability of the liver to conjugate glycine with benzoic

TABLE VI

MAXIMUM CAPACITY OF THE LIVER TO PRODUCE HIPPURIC ACID, AND THE AMOUNT OF GLYCINE REQUIRED FOR THIS PURPOSE

Subject	Dose Ingested		Hippuric Acid Excreted During Consecutive 15-Min Periods						Hippuric Acid Excreted During 90 Mins
	Glycine	Na-Benzate	1	2	3	4	5	6	
S L	1 5 Gm	6 Gm	21	36	50	54	60	52	2 73
	3 0 Gm	6 Gm	16	45	60	77	61	74	3 33
	4 5 Gm	6 Gm	15	47	61	69	69	77	3 38
	6 0 Gm	6 Gm	14	46	70	71			
E S	1 5 Gm	6 Gm	09	27	33	35	39	39	1 82
	3 0 Gm	6 Gm	00	32	38	47	46	56	2 19
	4 5 Gm	6 Gm	12	36	51	62?	72	76	3 09?
	6 0 Gm	6 Gm	18	47	66	79	74	78	3 62

Note The first three mixtures to each subject were given in divided doses, *i e*, two-thirds of the dose of each of the ingredients was given at the beginning of the test, and one-third one-half hour later

acid when both constituents were available in unrestricted amounts The results of this experiment are shown in Table VI We started out with a mixture containing approximately one-half the molecular equivalent of glycine to the molecular equivalent of sodium benzoate, and then increased the glycine to one, one and one-half, and two molecular equivalents In subject S L the maximum rate of synthesis was reached with the mixture containing molecular equivalents of glycine and sodium benzoate, while in subject E S it was reached with one and one-half molecular equivalents of glycine In the two subjects the maximum amount of hippuric acid synthesized in 90 minutes amounted to 3 38 and 3 62 Gm, respectively, far more than without the feeding of glycine The largest output was 0 79 Gm in 15 minutes, which corresponds to an hourly rate of 3 16 Gm, as against 1 92 Gm, which was the highest rate observed after the ingestion of 6 Gm of sodium benzoate but without the addition of glycine (see Table III)

CONCLUSIONS

(1) After the ingestion of 6 Gm of sodium benzoate, 12 healthy adult subjects eliminated 62 to 87 per cent of the ingested benzoate in four hours, with an average of 73 per cent This is an average of 3 7 Gm in terms of benzoic acid as compared with 3 Gm, Quick's normal average

The analytic method used for the estimation of hippuric acid in urine was the Weichselbaum-Probstein modification of Quick's method, the greater accuracy of the modified method accounts for the higher values in our experiments

(2) Four grams of sodium benzoate is the ideal dose to be used for liver function tests, since it is as fully capable of gauging the maximum rate at which the liver is able to synthesize hippuric acid as Quick's 6 Gm dose, at the same time causing far less gastric discomfort than the 6 Gm dose

(3) Twenty-four normal subjects who ingested 4 Gm of sodium benzoate eliminated 80 to 97 per cent of the drug in four hours, with an average of 88 per cent. The curve of the hourly rate of excretion is of a uniform character, the peak of excretion being reached during the second hour, 50 to 77 per cent of the sodium benzoate was handled during the first two hours.

(4) The rate of hippuric acid excretion during the first hour after the ingestion of sodium benzoate was doubled in four out of five subjects after the administration of glycine with the sodium benzoate.

(5) The maximum quantity of hippuric acid which could be synthesized when an adequate supply of both glycine and benzoic acid was available was 0.77 and 0.79 Gm (in terms of sodium benzoate), respectively, in a 15-minute period in two normal subjects.

II STUDIES ON PATIENTS

To date, we have applied the hippuric acid test, with the 4 Gm dose of sodium benzoate, to 103 patients, representing a variety of diagnoses, some of them tentative. The results were compared with the normal values described in the preceding chapter. On this basis it is assumed that in patients who in the course of four hours excrete less than 80 per cent of the ingested sodium benzoate, *i e*, less than the minimum excreted by normal individuals (see Table III), the liver function is impaired. Interpretation of the results is simple enough when the excretion is substantially below 80 per cent, it is difficult, however, to base conclusions upon figures that are near the border line. Yet these are just the cases which deserve greatest attention from the point of view of diagnosis. After all, when the liver function is shown by the test to be severely damaged, the test as a rule merely serves to confirm clinical observation and judgment, but a value of a much higher order consists in the detection of pathologic processes at such early stages where other approaches fall short.

Guided by this point of view, we attempted to carry out the hippuric acid test in a form which might permit a finer analysis and more satisfactory interpretation of the results in the border line cases. This is the reason why we placed the emphasis upon the hourly fractions of the hippuric acid excretion rather than the total of the four-hour period. Two figures in such fractional determinations proved to be enlightening. One is the time of appearance of the maximum amount excreted in a single hour, in normal subjects this amount appears almost invariably in the second-hour interval (Table III). The other figure is the sum of the two quantities excreted during the first and the second hours, this in normal subjects may be as high as 77 per cent, but always is at least 50 per cent. Now, in distinctly pathologic cases in which the total excretion during four hours is well below 80 per cent, the maximum hourly excretion may appear in any one of the four hourly intervals, and the sum of the excretion during the first two hours is considerably below 50 per cent. In border line cases, in which the total excretion closely approaches, and occasionally even slightly overlaps, the lowest limit of the normal, the maximum hourly excretion often shifts to the third hourly interval, and the sum of the two quantities ex-

creted during the first and second hours is always less than 50 per cent of the ingested benzoate. There are other border line cases in which the sum of excretion for the first two hours is 50 per cent or more, yet the level of excretion during the last two hours falls so abruptly that the total for four hours falls substantially below 80 per cent. These types of cases we consider as pathologic border line cases.

Inasmuch as the great majority of pathologic cases excrete less than 50 per

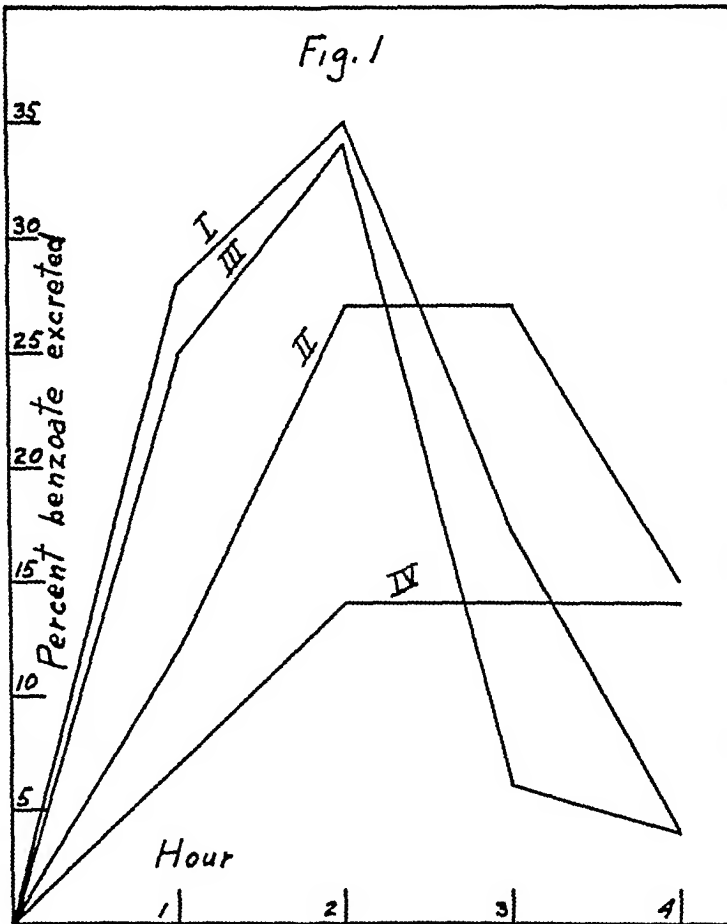


FIG. 1.—Curve I Normal subject No 6, Table IV Total elimination, 84 per cent. Curve II Border line case Patient No 16, Table VIII Total elimination, 81 per cent. Curve III Border line case Patient No 26, Table IX Total elimination, 69 per cent. Curve IV Definite impairment Patient No 4, Table VII Total elimination, 49 per cent.

cent (our lowest normal) in the first two hours, we feel that for most clinical purposes the test need be run for only two hours. A single determination of hippuric acid in a two-hour specimen is all that is necessary, with 50 per cent excretion being regarded as the lower limit of normal.

The relationships just pointed out are illustrated in Figure 1. Curve I represents a normal case (No 6 in Table III) with a total excretion of 84 per cent in the course of four hours, a figure that is near the lower limit of normal values. Curve II is a border line case (No 16 in Table VIII) in which the total excretion in four hours was 81 per cent, a figure that reaches up into the range of normal values, the excretion for the first two hours, however, was only 39 per cent, as against at least 50 per cent in normal cases. It may be

stated that this test was performed ten days after a cholecystectomy, a subsequent test, one week later, yielded normal values both as regards the hourly rate of excretion and the total for four hours. The other type of border line case is illustrated by Curve III. Here we have a patient (No. 26 in Table IX) who excreted 59 per cent, that is to say a normal quantity, during the first two hours, yet there was such a marked drop during the last two hours that the total excreted in four hours was only 69 per cent. Finally, Curve IV, representing a definitely pathologic case (No. 4 in Table VII), with a total excretion of 49 per cent, is included for comparison with the other three curves.

TABLE VII
HIPPURIC ACID TEST IN LIVER DISEASES

No.	Patient	Age	Sex	Diagnosis and Remarks	Blood NPN	Per Cent of Ingested Na Benzoate Excreted During				Total in Four Hours
						First Hour	Second Hour	Third Hour	Fourth Hour	
1	E. A.	31	Γ	Cirrhosis	19	9	3	7	7	26
2	M. B.	56	Γ	Cirrhosis	14	1	9	14	14	38
3	H. S.	55	M	Cirrhosis (biopsy)	20	19	32	24	7	82
4	J. F.	55	M	Cirrhosis (biopsy)	24	7	14	14	14	49
5	P. C.	43	Γ	Possible cirrhosis, icterus	14	5	No spec	18	5	28
6	M. Y.	60	M	Portal cirrhosis (?) Malignancy (?) Ascites, abdominal mass	18	7	12	11	10	40
7	N. C.	51	Γ	Hepatosplenomegaly, cirrhosis (?)	14	20	20	18	10	68
8	I. B.	64	Γ	Hepatomegaly, icterus Wassermann + + + +		10	13	27	10	60
9	L. S.	56	Γ	Hepatomegaly, icterus (Malignancy of bone?)	18	5	9	17	18	49
10	H. C.	49	M	Hepatomegaly (cirrhosis) Test after prostate operation	28	30	12	12	18	72
11	M. B.	68	Γ	Hepatomegaly, proliferative ar thritis	15	10	23	27	13	73
12	L. Γ	52	Γ	Hepatosplenomegaly, gastric hemorrhages	15	29	44	14	2	89
13	A. T.	48	M	Small liver, icterus (cause unknown)	16	10	23	15	21	69
14	R. E.	18	M	Catarrhal jaundice	18	12	17	9	—	38 (3 hrs)
15	B. L.	27	M	Catarrhal jaundice (3 days)	22	13	21	5	6	45
16	Γ. H.	30	M	Arsenical hepatitis	20	20	21	24		65 (3 hrs)
17	J. B.	38	M	Arsenical hepatitis (?)	38	30	12	12	18	72
18	R. T.	49	M	Subsided arsenical hepatitis, hepatomegaly still present	22	23	9	10	11	53

Of the 103 patients examined, 18 were diagnosed as suffering from various liver diseases. The results of the tests, presented in Table VII, show that all but two had a distinctly diminished capacity to synthesize hippuric acid. One (No. 4) of the exceptions was a case of cirrhosis, the other (No. 12) one of hepatomegaly.

In Table VIII are recorded 17 cases with biliary tract and gallbladder diseases. Of these, all but three showed distinctly an impairment of liver function. In two cases (Nos. 11 and 15) the hippuric acid was produced at the normal rate, while two cases (Nos. 13 and 16) gave border line results. It is interesting that all the cases of biliary tract obstruction showed impairment of the liver function.

LIVER FUNCTION

TABLE VIII

HIPPURIC ACID TEST IN BILIARY TRACT AND GALLBLADDER DISEASES

No	Patient	Age	Sex	Diagnosis and Remarks	Blood NPN	Per Cent of Ingested Na Benzoate Excreted During				Total in Four Hours
						First Hour	Second Hour	Third Hour	Fourth Hour	
1	S W	49	M	Stenosis of common duct or com- mon duct stone Jaundice, chills	14	18	27	20	9	74
2	M S	69	F	Stenosis of common duct, icterus 6/9/38	18	11	22		17*	50
				9/7/38		12	12	13	10	47
				4 wks after anastomosis of com- mon duct to jejunum						
				10/6/38		15	16	25	19	75
3	F B	36	F	Stricture of common duct 5/19/38	16	18	10	25	18	71
				6/10/38		20	28	21	8	77
				1/6/39		9	22	24	12	67
				1/14/39—1 wk. of high CH low fat diet		21	28	19	7	75
4	M S	50	M	After operation for stricture of common duct Patient still ic- teric Repeated after icterus subsided	23	17	20	23	6	66
						12	21	27	12	72
5	G D	71	M	Common duct stone (?), carci- noma of pancreas (?)	23	0	10	11	8	29
				After 8 days of high CH diet		4	24	9	13	50
6	W C	31	M	Recurrent obstructive jaundice	31	21	22	26	6	75
7	C B	52	F	Stenosis of common duct, icterus	20	13	13	15	22	63
8	J C	71	M	Obstructive jaundice Probable carcinoma head of pancreas	20	0	15	21	—	36 (3 hrs)
9	N L	33	M	Repeated attacks of pain in right upper quadrant Diagnosis (?)	18	10	27	25	14	76
10	F S	43	F	Cholecystitis, pituitary obesity	20	20	25	17	8	70
11	E G	50	M	Chronic cholecystitis, osteo- arthritis	16	51 (90 min)	18 (next 30 min)	13	6	88
12	L G	34	F	Chronic cholecystitis	16	9	21	29	8	67
13	E W	40	F	Cholecystitis (?), high blood cho- lesterol	20	9	34	16	21	80
14	S H	47	F	3 wks after operation for gall stones and hydrops of gallbladder	13	19	28	23	—	70 (3 hrs)
15	T P	28	F	12 days after cholecystectomy	13	32	25	24	4	85
16	M R	56	M	Acute cholecystitis 10 days after operation	21	12	27	27	15	81
				17 days after operation		20	33	20	11	84
17	F S	29	F	Acute gangrenous cholecystitis 10 days after operation	15	6	26	16	6	54
				17 days after operation		23	33	15	8	79

* Combined excretion for third and fourth hours

Table IX contains 26 cases with a variety of diseases which show impaired liver function. It may be noted that in diabetes, in several forms of arthritis, in hyperthyroidism, and in cardiac diseases some of the patients showed impaired liver function, while others had normal liver function so far as the ability to produce hippuric acid is concerned.

In some cases repetition of the hippuric acid test proved to be of value in demonstrating changes in the condition of the liver. In the chart which comprises Figures 2 to 5, the improvement of the liver function is shown in the form of hourly rate curves of hippuric acid excretion. Figure 2 is the graphic

presentation of Case No 2 of Table VIII, showing the substantial recovery of liver function three weeks after surgical operation for stenosis of the common duct. Figure 3 (Case No 5 in Table VIII) illustrates a distinct improvement as a result of dietary regulation. Figure 4 illustrates the return of impaired liver function to normal five days after a marked sulfanilamide reaction, and Figure 5 exhibits a similar picture six weeks after aniline poisoning. Table VIII contains a few more similar results after surgical operations in diseases of the gallbladder and of the biliary tract.

TABLE IX

MISCELLANEOUS DISEASES SHOWING IMPAIRED LIVER FUNCTION

No	Patient	Age	Sex	Diagnosis and Remarks	Blood NPN	Per Cent of Ingested Na-Benzotate				Total in Four Hours
						First Hour	Excreted During Second Hour	Third Hour	Fourth Hour	
1	M H	50	M	Diabetes mellitus†		20	20	25	12	77
2	P E	64	M	Diabetes, gangrene of foot	16	28	36	6	3	73
3	B F	49	F	Diabetes, marked hypercholesteremia	15	4	27	6	9	46
4	P R	60	M	Arthritis‡	23	2	38	19	9	68
5	H G	60	F	Proliferative arthritis, gout	22	16	25	30	7	78
6	L A	41	M	Spondylosis	15	18	42	11	2	73
7	C P			Degenerative arthritis, iritis	22	17	28	25	10	80
8	E S	49	F	Proliferative arthritis	16	15	12	15	22	64
9	M G	10	F	Proliferative arthritis, obesity	23	10	16	16	14	56
10	M L	23	F	Hyperthyroidism, B M R +45	16	15	8	15*	21	51
11	A J	56	F	Hyperthyroidism, B M R +21	20	4	25	23	17	69
12	B M	36	F	Hyperthyroidism, B M R +2	18	20	23	24	8	75
13	E O	66	M	Hypertensive heart disease	23	13	21	10	23	67
14	C C	58	M	Degenerative heart disease	17	10	6	23	18	57
15	M L	76	F	Hemorrhage into thyroid (?)	31	0	0	0	0	0
16	M G	50	F	Chronic pancreatitis	15	4	7	8	5	24
17	E S	14	F	Residual poliomyelitis	17	12	5		3*	20
18	S F	36	F	Sciatica	21	22	41		5*	68
19	C K	37	F	Undulant fever	13	10	11	15	6	42
20	H L	59	M	Xanthomatosis, hypercholesteremia	22	22	30	15	7	74
21	M F	26	F	Hypercholesteremia	20	19	5	28	14	66
22	J S	31	M	Marked reaction to sulfanilamide	17	15	16	14	12	57
23	M G	14	M	Aniline dye poisoning		10	16	26	15	67
24	T L	54	F	Carcinoma of the colon, no liver metastasis	18	23	23	21	8	75
25	F M	56	M	Asthma	18	20	31	16	7	74
26	H C	33	M	Syphilis, pachymeningitis hemorrhagica	16	25	34	6	4	69

* Combined excretion for this and preceding hour

† In three other diabetics, the test gave normal results

‡ In 11 other cases of arthritis, the results were normal

§ In two other cases of hyperthyroidism, the results were normal

|| In two other cases of hypertensive heart disease results were normal

Attention has been directed to the influence of renal function upon the result of the hippuric acid test. Deficient renal function may depress the rate of excretion of hippuric acid and, thereby, a picture may result which indicates impaired liver function. Some workers regarded it necessary, therefore, to ascertain in doubtful cases that renal function is normal, by performing urea clearance tests together with the hippuric acid test. However, Quick⁵ said that

the rate of hippuric acid excretion by the kidneys is 50 per cent higher than the rate of the synthesis of that compound in the liver, and that, as a consequence, only very serious disorders in kidney function could affect the elimination of hippuric acid Snapper and Grunbaum⁶ observed hippuric acid retention in nephritic patients only when retention of urea was demonstrable On examination of the tables in the paper of Fouts, Helmer and Zerfas,⁹ one finds instances in which the rate of excretion of hippuric acid is normal despite greatly diminished urea clearance

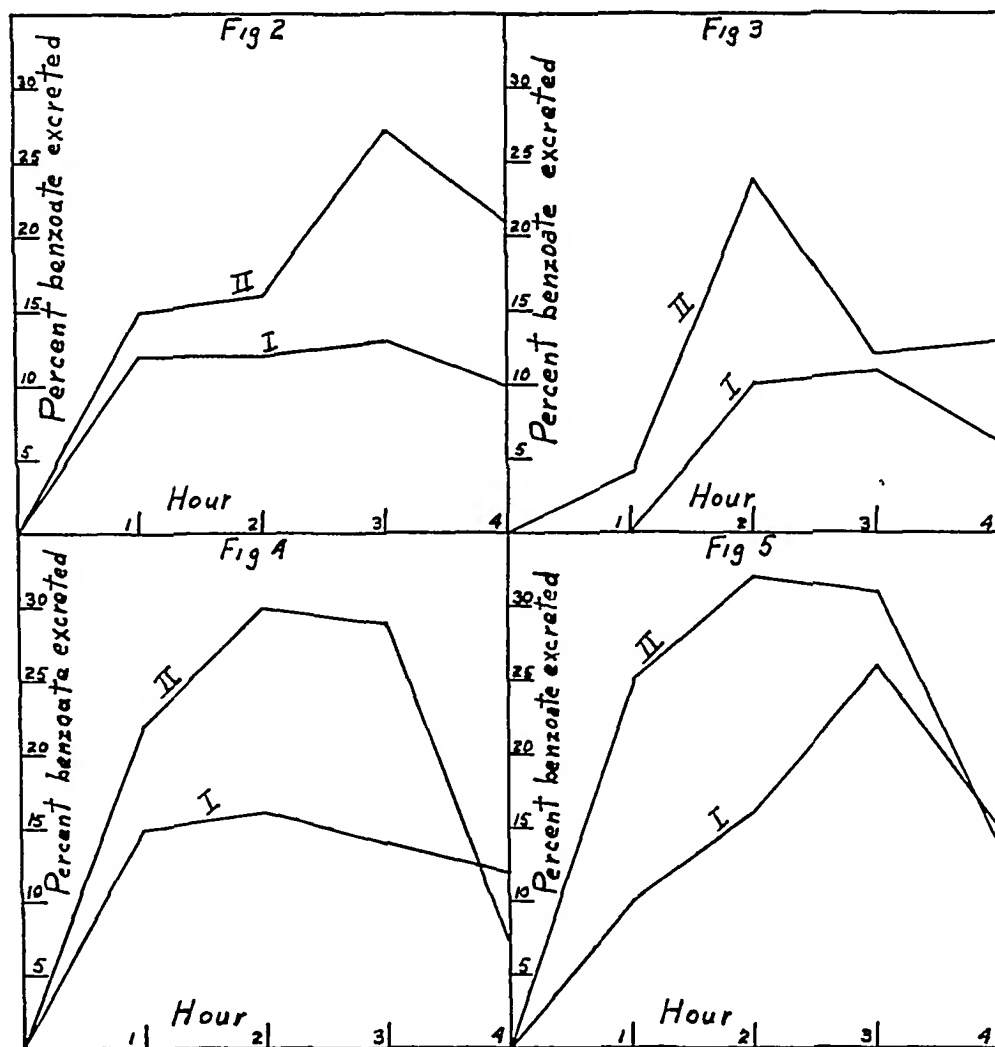


FIG 2—Stenosis of common duct Curve I, before operation Curve II, improvement four weeks after operation

FIG 3—Obstructive jaundice due to common duct stone, or carcinoma of the head of the pancreas Curve I, soon after the patient's admission to the hospital Curve II, improvement following eight days of high carbohydrate diet

FIG 4—Sulfanilamide reaction Curve I during reaction to drug Curve II, normal test during recovery

FIG 5—Aniline dye poisoning Curve I test while patient was ill Curve II, several weeks after patient's discharge from the hospital

In considering this question we have borne in mind that Van Slyke and his coworkers¹⁰ have shown that only when urea clearance is 50 per cent or less do we begin to find cases with retention of urea, and that only when the urea clearance is 20 per cent or less do all cases show a retention of urea In view

of these facts, and of Snapper and Grunbaum's observation, we are not surprised to find that there is no constant correlation between reduced urea clearance and diminished excretion of hippuric acid. Thus we see in Table X,

TABLE X

EFFECT OF IMPAIRED KIDNEY FUNCTION UPON THE EXCRETION OF HIPPURIC ACID

No	Patient	Age	Sex	Diagnosis	Urea	Blood	Per Cent of Ingested Na Benzoate Excreted During				Total in Four Hours
					Cl Per Cent	Urea N	First Hour	Second Hour	Third Hour	Fourth Hour	
1	A W	24	Γ	Chronic nephritis	30	14		39*	29	14	82
2	M B	54	Γ	Kidney damage following transfusion reaction	40	12	20	34	24	11	89
3	C W	51	M	Proliferative arthritis	53	13	23	35	23	5	86
4	S S	52	Γ	Proliferative arthritis	41	14	26	27	24	5	82
5	F J	58	M	Gout	57	14	17	31	21	12	81
6	F A	68	M	Acute infectious arthritis	33	31	22	35	17	7	81
7	J Γ	45	M	C N S syphilis		20	26	27		32*	85
8	M L	49	M	Bronchial asthma		28	22	23	26	8	79
9	D J	55	M	Gangrene of feet		28	0	7	6	1	14
10	C T	56	M	Hypertensive heart disease		21	5	15	18	18	56
11	H H	51	M	Cardiorenal		20	0	3	3	6	12
12	M B	46	F	One kidney	19	22	10	16	16	7	49
13	Γ G	63	Γ	Gout arteriosclerosis		22	17	26	5	7	55
14	D A	60	M	Cardiorenal		110	0	0	0	0	0

The urea N values in the patients who did not have urea clearance tests were calculated from the NPN values determined on zinc filtrates of blood according to the method of Somogyi.¹¹ According to his figures the upper limit of normal blood urea is 19 mg per cent.

* Combined excretion for this and preceding hour.

which contains the results of the hippuric acid test in patients with various degrees of impairment of kidney function, that patients Nos 1 to 5 with urea clearances of 30 to 57 per cent, but with normal values for blood urea, all show normal values in the hippuric acid test. On the other hand, patients Nos 9 to 14, with varying degrees of urea retention, all show diminished excretion of hippuric acid, patient No 14 of this group, with a urea nitrogen of 110, did not excrete any hippuric acid at all during the entire four hours. But even in some of these instances we cannot say that the impaired renal function is responsible for the diminished hippuric acid excretion, since patients Nos 6 to 9 give normal or near normal responses to hippuric acid tests, despite increased urea contents in the blood.

Taking these observations into consideration, we are persuaded that only in the presence of marked diminution of renal function which is associated with increased urea content of the blood is the excretion of hippuric acid affected by the renal factor. It is, therefore, unnecessary to perform the urea clearance test for the proper interpretation of the hippuric acid test. Knowledge of the urea or nonprotein nitrogen content of the blood suffices, and only when these are higher than normal need the interpretation of low hippuric acid output be in doubt.

A question which merits consideration concerns the factor or factors which cause the diminution of hippuric acid formation in the liver in pathologic cases.

Quick⁵ believes that the reduction is due primarily to a diminished capacity of the liver to synthesize glycine, and in part to damage of the enzymatic mechanism which unites benzoic acid with glycine. We inquired into this question by administering 5 Gm of glycine plus 4 Gm of sodium benzoate to six patients who had previously been found to have definitely decreased capacity to produce hippuric acid when they were given sodium benzoate only. In Table XI it

TABLE XI

RESPONSE TO ADMINISTRATION OF GLYCINE PLUS SODIUM BENZOATE IN PATIENTS SHOWING AN IMPAIRMENT OF LIVER FUNCTION BY THE HIPPURIC ACID TEST

No	Patient	Diagnosis	Remarks	Per Cent of Ingested Na Benzoate Excreted During				Total in Four Hours
				First Hour	Second Hour	Third Hour	Fourth Hour	
1	M S	Stricture of common duct	Without glycine	16	20	23	6	65
			With glycine	30	45	12	4	91
2	M L	Hyperthyroidism	Without glycine		15*	15	21	51
			With glycine	26	42		14*	82
3	B S	Stenosis of common duct	Without glycine	12	12	13	10	47
			With glycine	27	32	20	6	85
4	J F	Portal cirrhosis	Without glycine	7	14	14	14	49
			With glycine	3	23	16	8	50
5	A T	Small liver, jaundice	Without glycine	11	14	22	16	63
			With glycine	10	14	20		44 (3 hrs)
6	E S	Proliferative arthritis	Without glycine	15	12	15	22	64
			With glycine	45	36	7	3	91

* Combined excretion for this and preceding hour

can be seen that only patient No. 6 responded as did our normal subjects to the addition of glycine to the test (*cf* Table V), in that this patient was able to excrete 45 per cent of the ingested benzoate during the first hour when glycine was added. In this instance, one can say that the impairment of liver function concerned mainly the diminished capacity of the liver to furnish glycine. On the other hand, although patients Nos. 1 to 3 responded with an increased elimination of hippuric acid when glycine was added, this increase was considerably smaller during the first hour than was observed in any of our normal subjects under similar conditions. In these instances a definite slowing down of the rate of the conjugation process as well as in the production of glycine occurred. Finally, patients Nos. 4 and 5 showed no response at all to the administration of glycine, indicating a marked impairment of the enzymatic mechanism which unites benzoic acid with glycine.

From these observations it may be concluded that in some patients the main defect consists in the diminished ability of the liver to furnish glycine, while in others the enzymatic conjugation process is defective. The two deficiencies may be present simultaneously. By performing the double test as was done in these six patients, it may be possible to gauge two distinct liver functions, namely, glycine synthesis, and the conjugation of benzoic acid with glycine. Further observations will be necessary before the merits of such double tests can be evaluated.

CONCLUSIONS

(1) For Quick's liver function test, 4 Gm of sodium benzoate as the standard dose is superior to the 6 Gm dose

(2) Estimation of the hippuric acid excretion at hourly intervals, in addition to determination of the total amount eliminated during the course of four hours, enhances the values of the test in that it permits evaluation of the degree of severity of the liver impairment

On this basis we classify the cases as follows

(a) Marked or severe impairment where both the total elimination and the maximum excretion in a single hour (maximum hourly rate) are subnormal

(b) Mild degrees of impairment, where the total hippuric acid eliminated in four hours is but slightly depressed or is a low normal, but where the amount eliminated in the first two hours is below 50 per cent of the ingested benzoate

(c) Borderline cases, in which the elimination in the first two hours is 50 per cent or more, but in which the total elimination for the entire period is somewhat depressed

The lines of demarcation between these three groups are, of course, not sharp

(3) On the basis of our tabulated results we consider an abbreviation of the test to a two-hour period as quite satisfactory for most clinical purposes. In this form of the test, the analytic work is reduced to a single determination of hippuric acid in the total urine excreted during two hours. If the hippuric acid excreted in two hours represents 50 per cent or more of the ingested 4 Gm of benzoate, this may be accepted as a sign of normal liver function in respect to the process involved

(4) The usefulness of the test is not affected by impaired renal function unless this attains such a degree of severity as to be associated with retention of urea

(5) A few of our experiments indicate that, whereas, subnormal results in the hippuric acid test are to be ascribed mainly to a deficiency in the ability of the liver to supply glycine at a normal rate, there are cases in which the main cause may be ascribed to a deficiency in the mechanism responsible for the conjugation of benzoic acid with glycine

We are indebted to Dr Avery Rowlette and the resident staff of the St. Louis City Hospital for furnishing us some of our cases

REFERENCES

- ¹ Delprat, G. D., and Whipple, G. H. Studies of Liver Function. Benzoate Administration and Hippuric Acid Synthesis. *Jour Biol Chem*, 49, 229, 1921
- ² Quick, A. J. The Study of Benzoic Acid Conjugation with a Direct Quantitative Method for Hippuric Acid. *Jour Biol Chem*, 67, 477, 1926
- ³ Quick, A. J. The Synthesis of Hippuric Acid. A New Test of Liver Function. *Am Jour Med Sci*, 185, 630, 1933

- ⁴ Weichselbaum, T E, and Probst, J G Determination of Hippuric Acid in Urine Jour Lab and Clin Med, 24, 636, March, 1939
- ⁵ Quick, A J Clinical Value of the Test for Hippuric Acid in Cases of Disease of the Liver Arch Int Med, 57, 544, 1936
- ⁶ Snapper, J, and Grunbaum, A Der Hippursäure-Stoffwechsel bei Nierkrankheiten Klin Wchnschr, 3, 103, 1924
- ⁷ Quick, A J, Ottenstein, H N, and Weltchek, H Synthesis of Hippuric Acid in Man Following Intravenous Injection of Sodium Benzoate Proc Soc Exper Biol, 38, 77, 1938
- ⁸ Quick, A J The Conjugation of Benzoic Acid in Man Jour Biol Chem, 92, 65, 1931
- ⁹ Fouts, P J, Helmer, O M, and Zerfas, L G The Secretion of Hippuric Acid in Pernicious Anemia Am Jour Med Sci, 193, 647, 1937
- ¹⁰ Van Slyke, D D, McIntosh, J F, Mollere, E, Hannon, R R, and Johnston, C Studies of Urea Excretion II Comparison of the Blood Urea Clearance with Certain Other Measures of Renal Function Jour Clin Invest, 8, 357, 1929-1930
- ¹¹ Somogyi, M Nitrogenous Substances in Zinc Filtrates of Human Blood Jour Biol Chem, 87, 339, 1930

STUDIES ON THE CAUSE OF DEATH IN TETANUS*

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IN 1903, Meyer and Ransom¹ reported some experiments upon cats and rabbits in which large and rapidly fatal doses of tetanus toxin were injected into the substance of the lumbar segment of the nontransected spinal cord. These and other experiments² of Meyer's were carefully repeated upon dogs, in 1935, by Firor and Jonas³. They were able to show, as Zupnik⁴ had suggested in 1902, that spinal injections of toxin can produce tactile reflex motor tetanus without inducing any sign of the muscular rigidity which complicated Meyer's experiments and fortified his belief that both the muscular rigidity and the reflex convulsions of tetanus were of solely central origin. In repeating Meyer's experiments the amount of toxin injected into any one dog's lumbar cord (a nonvital center) was very much smaller (1/4 to 1/150) than the amount required to kill the animal had the toxin been injected intravenously, subcutaneously, or intramuscularly. And yet in each of the 11 experiments the dog died within a week. It was this unexpected and early death which first gave rise to the suspicion that tetanus toxin may be altered when in contact with the cells of the spinal cord.

In an attempt to confirm our suspicions, we carried out the experiments described in a paper published in 1938, entitled "The Apparent Alteration of Tetanus Toxin Within the Spinal Cord of Dogs"⁵. We related there the facts which led us to entertain the possibility of such alteration. In order to establish without any doubt the pattern of reaction for each experiment reported in that paper, we have enlarged our series in each category. The present paper tabulates these experimental results to date. We were also anxious to find more definite proof, or disproof, of the apparent alteration of the toxin. Our further attempts, together with some related experiments, occupy the latter part of this communication.

To avoid too much repetition we have omitted from this paper the complete descriptions of *Methods of Procedure* and the *Protocols of Typical Experiments* that appeared in our earlier paper, and in an effort to clarify the discussion we have altered somewhat the order in which the various experiments were presented in the previous paper. However, to facilitate reference to the more detailed descriptions of procedures, we have indicated in parentheses under each experiment in the present paper the corresponding sections of our earlier paper.

Notes on Dosage, Toxins, Abbreviations Used in the Tables, Symptoms etc—Although in keeping our records and in calculating our doses our standard unit was the guinea-pig median lethal dose (or LD₅₀), we have in this paper expressed our doses as

* These studies were made possible by a grant from The John and Mary R. Markle Foundation.

multiples or fractions of a lethal dose for the animal concerned. Our lethal dose is the minimum dose which always kills the animal when injected intravenously, intramuscularly, or subcutaneously.⁶ Our lethal dose for the dog is 480 guinea-pig LD₅₀'s per kilogram of dog's weight (see footnote 4 of Paper VII in Doctor Abel's⁷ series), for cats and rabbits 960 guinea-pig LD₅₀'s per kilo, and for monkeys four guinea-pig LD₅₀'s per kilo.

Concentrated* tetanus toxin was supplied by Doctor Hampil of Sharp and Dohme, Inc., and by Doctor Malcolm of the Lederle Laboratories. The toxin was kept in sterile rubber-stoppered vials at 2° to 4° C. The strength of the toxin was frequently assayed on guinea-pigs. For further details regarding the preparation of the toxins and methods of assay the reader is referred to Section II of Paper V in Doctor Abel's⁸ series. Doctor Brewer of Hynson, Westcott, and Dunning performed sterility tests on the toxins.

Large amounts of concentrated tetanus antitoxin were supplied by Sharp and Dohme, Inc.

Our injecting syringe has been described earlier.⁵ With this syringe we can inject accurately as little as 0.0005 cc. of fluid.

TRTM—In our tables we use this abbreviation for tactile reflex motor tetanus, by which we mean that the reflex activity of that part of the spinal cord which has been injected with toxin is so greatly exaggerated that in the *advanced* stage of this condition there are almost continuous extensor convulsions without any of the other symptoms of tetanus. Since in most of our experiments we injected the lumbar cord, the reflex motor tetanus was limited to the muscles of the hind limbs with the occasional involvement of some of the lower trunk muscles. The first sign to appear is hyperactivity of the deep reflexes. Later, testing the deep reflexes may produce a slight extensor clonus. If the animal is standing on all fours a pat on the lower end of the spine will cause the animal to extend his hind legs so sharply that his rump appears to bounce up. A little later the mere pressure of the animal's own weight when standing is sufficient to produce series of rapid extensor thrusts so that the hind legs appear to be dancing. Shortly thereafter the slightest tactile stimulus is enough to initiate exaggerated extensor thrusts. The symptoms are described in more detail by Firor and Jonas³ in their protocols and by ourselves.⁵

Onset of Symptoms—One column in the tables indicates the length of time between injection of toxin and onset of symptoms. It should be noted, however, that the animals were, in many instances, not examined frequently enough to detect the beginning of symptoms, and that, therefore, the number of hours in this particular column is not an accurate measure of the time required for the appearance of symptoms.

(I) *Infection of Toxin Into the Central Nervous System*—EXPERIMENT I (cf. Expt 2 in our previous report). To show that the injection of less than one lethal dose of tetanus toxin into an anterior horn of the lumbar cord can cause death, we have frequently repeated the operation used in 1937 by Firor and Jonas³ and also described by us.⁵ This procedure makes it possible to deposit the toxin in the anterior horn area with more accuracy than any other method we have tried. Counting all dogs, regardless of the size of the doses of toxin, a total of 196 dogs have been injected in the intact lumbar cord. For the sake of brevity these dogs are hereafter usually referred to as "intact cord dogs." One hundred dogs received less than one lethal dose, 46 dogs received more than one lethal dose, 23 dogs sacrificed for other experiments and not included, 27 dogs used in antitoxin experiments described later. The results of the operations on the first group of 100 dogs are given in Table IA.

* Our toxins varied in strength from 50,000 to 375,000 guinea-pig LD₅₀'s per cubic centimeter. It would require only 0.0007 cc. of our strongest toxin to kill a man weighing 154 pounds.

TABLE I A

INJECTION OF LESS THAN ONE LETHAL DOSE OF TETANUS TOXIN INTO THE INTACT
LUMBAR CORD*All Autopsies Normal Unless Otherwise Noted*

A DOGS

Fraction of Lethal Dose Injected	Number of Animals	Onset of Symptoms in Hours	Symptoms	Survival in Days		Autopsy and Remarks
				Range	Average	
1/2000	1		None		Indefinite	
1/1000	4		One had slightly increased reflex excitability		Indefinite	
1/500	1	48	Marked TRMT	4 days *		
	1	120	Mild TRMT which disappeared		Indefinite	
	1		Questionable increase in reflexes		Indefinite	
	4		No symptoms		Indefinite	Reinjected †
1/400	2	80	Marked TRMT	9 days 12 days		Infection of cord
	5	100	TRMT which disappeared		Indefinite	Four reinjected
	1	94	Atypical TRMT	9 days		
	4		Questionable increase in reflexes		Indefinite	Two reinjected
1/300	1		No symptoms		Indefinite	Reinjected
	1		Questionable increase in reflexes which disappeared		Indefinite	
1/250	2	96	TRMT which disappeared		Indefinite	
1/200	3	50	TRMT	3-7	4 4	
	2	100	TRMT which disappeared		Indefinite	
1/100	2	48	TRMT	5-7	6	
1/50	5	48	TRMT	3-7	4 6	
1/25-1/15	17	40	TRMT	1-3	2 4	
	1	96	TRMT and stiffness		6	Cord injured at operation
	3		No symptoms †	2-17	8	Had pneumonia
	3		No symptoms †		Indefinite	Reinjected
	1		No symptoms †		4	Normal
Survival in Hours						
1/10	10	20-30	TRMT	30-44	42	
	2	42	TRMT		86	
	11	20	TRMT	24-60	33	
1/8-1/3	1	72	TRMT and stiffness		144	Cord injured at operation
1/2	11	15-17	TRMT	18-53	38	

TABLE I B

B CATS

Fraction of Lethal Dose Injected	Num- ber of Ani- mals	Onset of Symp- toms in Hours	Symptoms	Survival in Hours		Autopsy and Remarks
				Range	Aver- age	
1/400	1	96	TRMT	120		The following animals were also injected with similar results 4 rabbits 4 guinea-pigs 2 monkeys
1/150	2	60	TRMT	120		
1/80	1	48	TRMT	60		
1/40-1/20	2	42	TRMT	78		
1/10-1/2	3	22	TRMT	24		

* In the case of this dog the toxin was roughly diluted to a strength suitable for the injection. He probably received more than 1/500. Subsequently our dilutions were made with considerable accuracy, and under nitrogen to avoid oxidation.

† A number of dogs were reinjected with varying doses of toxin. We have not performed enough of these experiments to justify any deductions in regard to the effect of repeated small doses of toxin in the cord.

‡ All seven dogs were experimented upon before we had perfected our operating and injecting technique.

Tables IA and B reveal that injection into the intact cord has several points of similarity to intravenous injections of toxin.

- (1) An incubation period before the onset of symptoms, the length of which in general varies inversely with the amount of toxin injected.
- (2) A survival period the length of which in general varies inversely with the amount of toxin injected.*
- (3) The possibility of injecting (a) so little toxin as to produce no symptoms, or (b) enough to produce symptoms from which the animal later entirely recovers, or (c) an amount that always causes death.
- (4) Individual variations in sensitivity to the toxin.

The table also reveals that usually in any one group of animals the period of incubation and of survival is longer in some individuals than in most of the other animals in their group. We feel that in addition to individual variation in sensitivity to toxin we may explain these differences by presuming that in these dogs the point of the injecting needle was not entirely within the motor area. The two dogs that developed stiffness suffered trauma to the cord during the operation. We have found, as did Firor and Jonas, that trauma to the cord almost always causes stiffness and prolongation of life. This factor is discussed below under Experiment 4.

Whenever these animals were observed at the time of death it was noted that respirations became slow and irregular before ceasing, but that the heart continued to beat for a minute or two, and not infrequently for as long as five minutes, after respirations had stopped. There was no rigidity or spasm of any of the muscles concerned with respiration as is often reported in patients.

* It follows from (1) and (2) that if an animal has received enough toxin to kill him, the sooner symptoms appear the sooner the animal dies.

with tetanus dying of respiratory failure. Other observations on these animals are given later in this paper in discussing possible explanations for their death.

We also injected less than a lethal dose of tetanus toxin into the lumbar cord of cats, rabbits, monkeys, and guinea-pigs (Table IB) in order to show that such injections cause limited tactile reflex motor tetanus and invariable death in animals other than dogs*. It is of interest to note that our cats did not have hyperpyrexia before death such as was almost always found in dogs dying as a result of these injections.

In Table IC we give the results of injecting into the intact cord more than one lethal dose. In Table ID we summarize our controls. The operations on the control animals were exactly similar to the operations on the experimental animals. The inclusion of the seven controls reported by Firor and Jonas³ is permissible because the operations on these dogs were exactly similar to our operations.

TABLE IC

INJECTION OF MORE THAN ONE LETHAL DOSE OF TETANUS TOXIN INTO THE INTACT LUMBAR CORD

Number of Lethal Doses Injected	Number of Dogs	Onset of Symptoms in Hours	Symptoms	Survival in in Hours		Survival in Days If the Toxin Had Been Injected <i>Per Venam</i> *
				Range	Average	
15	37	10-12	TRMT	11-50	20	6
30	7	6	TRMT	10-19	17	5
50	2	6	TRMT	9-12	10.5	5

* These figures are taken from a number of experiments performed by Doctor Abel and his coworkers and by ourselves.

TABLE ID

CONTROL OPERATIONS AND INJECTION OF OTHER MATERIALS

Materials Injected	Number of Dogs	Survival in Days		Remarks
		Range	Average	
Staphylococcus toxin, diphtheria toxin, water, broth, needle punc- tures	8	8-120	40	Sacrificed or given away
	2	10-15	12	Died of pneumonia
Beef extract or veal infusion broth	4	Indefinite		} Reported by Firor and Jonas ³
Boiled tetanus toxin	3	Indefinite		
Dogs in Table I that received small doses of tetanus toxin but lived indefinitely	29	Indefinite		

* Although our experiments on animals other than dogs are too small in number to allow any positive statements to be made in regard to them, we suspect that in order to produce death by injecting toxin into the spinal cord, relatively larger fractions of a lethal dose are required for animals that are very sensitive to the intravenous injection of toxin than for less sensitive animals. For further studies on this point see J. Immunol., 37, 425, 1939.

We also injected less than one lethal dose of tetanus toxin into levels of the spinal cord other than the lumbar enlargement with similar results. Just as injection of the lumbar cord causes tactile reflex motor tetanus limited to the hind limbs, so, for example, injection of the cord in the cervical segment (C VI) produces tactile reflex motor tetanus limited to the forelegs. We have not studied the survival period after injection of toxin into sensory areas of the medulla spinalis or oblongata because such injections invariably produce tetanus dolorosus. We have noted, however, that symptoms develop at the same time as in the motor area injections, and we believe that the survival period would also be the same as in the motor area injections.

For various reasons, which we shall discuss later, we desired to inject tetanus toxin into the region of the respiratory centers of dogs.⁹ EXPERIMENT 2 (*cf* Expt 4 in our previous report). Toxin was injected into the medulla oblongata at the obex in 61 dogs. For the sake of brevity these dogs are hereafter usually referred to as "medulla dogs." Sixteen of these were sacrificed for other experiments, and in 11 dogs the outcome was complicated by additional procedures or by other pathologic conditions, such as pneumonia. The remaining 34 dogs and the controls are presented in Table II.

It is apparent that almost all the comments made in reference to Table I apply equally to Table II. There are the same points of similarity to intravenous injections of toxin. In general the variations of survival in any one group of medulla dogs are less than in the intact cord dogs. This is probably due to the fact that in the medulla dogs there is little chance of inserting the needle so deeply as to pass entirely through the cord, and, therefore, there is more chance of depositing the whole dose within the neural substance.

The manner of death was the same as in the intact cord dogs: there were no spasms of the respiratory muscles that could have suffocated the dogs, the heart continued to beat after respirations had ceased. In a few animals picrotoxin was injected intravenously in an attempt to stimulate the respiratory center.¹⁰ These attempts were futile.

At autopsy the dogs dying from injections of diphtheria toxin had gross and extensive areas of hemorrhagic necrosis about the site of injection, these areas were sometimes as large as 2 to 3 Mm in diameter. Diphtheria toxin placed in the lumbar cord produces a similar hemorrhagic necrosis causing flaccid paralysis of the hind limbs but not death.

The dogs injected with morphine received from 0.20 to 1.07 mg of morphine sulphate per kilogram of body weight. Our solutions of morphine were made up in distilled water and contained from 80 to 160 mg per cc. Within 15 minutes after the injection the animals' respirations became depressed and there appeared signs of medullary irritation somewhat similar to those which develop in dogs which had received tetanus toxin in the medulla. It is interesting that the injection of morphine, a known respiratory depressant, into the medulla at the obex produces almost immediate slowing of the respirations.

It should be noted that the incubation period before the onset of symptoms is still present even though we inject into the medulla an amount of toxin 2,500 times greater than what we may call an "intramedullary lethal dose," and that there is still a considerable period between the onset of symptoms and the death of the animal.

There are three chief differences between the intact cord and the medulla dogs: (a) In the medulla dogs smaller doses of toxin suffice to cause death

TABLE II

INJECTIONS OF TETANUS TOXIN INTO MEDULLA OBLONGATA AT OBEX

All Autopsies Normal Unless Otherwise Stated

A EXPERIMENTAL

Fraction of Lethal Dose Injected	Number of Dogs	Onset of Symptoms in Hours	Symptoms	Survival in Hours		Autopsy
				Range	Average	
1/4500	2		None	Indefinite		
1/2000	1	48	Pharyngeal spasms	144	192	{ Pneumonia Thin
	1	168	Pharyngeal spasms	240		
	1		None	Indefinite		
1/1000	1	144	Pharyngeal spasms	408		Lost 30% weight
	3	132	Pharyngeal spasms	144-216	184	
1/500	2	24-48	Pharyngeal spasms	72-216	144	
1/40	3	18-24	Pharyngeal spasms	27-60	43	
1/20	2	5	Pharyngeal spasms	22-24	23	
1/15	5	7	Pharyngeal spasms	18-27	22	
1/10	7	6	Pharyngeal spasms	17-26	21	
1/5	2	Not seen	Pharyngeal spasms	17-19	18	
2 5	2	2	Pharyngeal spasms	10-12	11	
3 0	2	2	Pharyngeal spasms	9-11	10	

B CONTROL

Number of Dogs	Material Injected	Amount in Cc	Symptoms	Survival in Hours	
				Range	Average
1	Diphtheria toxin	0 0005	None	312	
3	Diphtheria toxin	0 001	None	19-23	21
3	Diphtheria toxin	0 002	None	23-36	29
2	Diphtheria toxin	0 003	None	15-40	27
2	Diphtheria toxin	0 004	None	15-17	16
2	Diphtheria toxin	0 006	None	9-19	14
5	Diphtheria toxin	0 008	None	17-23	19
3	Diphtheria toxin	0 01	None	8-33	17
5	Other bacterial toxins*	0 005	None	Indefinite	
1	Blood	0 006	None	Indefinite	
2	Water	0 004	None	Indefinite	
6	Tetanus spores and lactic acid	0 005	None	Indefinite	
5	Morphine sulphate	0 016- 0 030	Yes	Indefinite	
1	Needle punctures and hemorrhage		None	Indefinite	

* Colon, typhoid, Staphylococcus, and meningococcus toxins

See also the dogs used by Gesell, Bricker, and Magee, in which sharp needles and electrodes were put into the medulla

than in the intact cord dogs (b) With equal doses symptoms appear earlier in the medulla group (c) When given equal doses of toxin the medulla dogs die about twice as quickly as the intact cord dogs

In 12 dogs we injected toxin into the brain Two dogs received $\frac{1}{4}$ to $\frac{1}{2}$ lethal dose in the vermis They both developed typical signs of cerebellar dysfunction and died in two and eight days Ten dogs received $\frac{1}{25}$ to $\frac{1}{2}$ lethal dose in the frontoparietal area Of these, five dogs developed no symptoms and survived indefinitely Five dogs developed symptoms of varying degree but only two dogs died, in two and nine days, the other three survived indefinitely Apparently the injection of toxin into the brain is seldom fatal It is interesting to recall that patients with tetanus exhibit few signs of cerebellar irritation We hope to increase our series of injections into the brain and to discuss in a later paper the differences between injections into the brain and into the spinal cord

(II) *Injection of Toxin Into Organs Other Than the Central Nervous System*—To show that less than one lethal dose does not kill when injected into organs other than the central nervous system we have made injections into veins, liver, spleen, testis, the anterior chamber of the eye, the spinal fluid, and motor roots All these dogs lived indefinitely and exhibited no symptoms We may also add the 13 dogs injected in the sciatic nerve by Abel, Hampil, and Jonas¹¹ Two dogs injected in a sympathetic ganglion showed pupillary changes but they survived indefinitely Dr A M Harvey has written (1938) that he has had similar results with five dogs

Since a small fraction of a lethal dose of tetanus toxin placed in the nonvital lumbar cord invariably kills the animal, and since such minute amounts of toxin put into any organ other than the central nervous system fail to kill the animal, we must find some explanation for the deaths

(III) *The Factor of Muscular Contractions*—EXPERIMENT 3 (cf Expt I in our previous report) To show that exhaustion of abnormal metabolites produced by the constant clonic seizures is not responsible for death, we severed the conus and two to three pairs of adjacent spinal roots and then immediately injected toxin into the mobilized end of the cord a centimeter or two proximal to the site of transection For the sake of brevity these dogs are hereafter usually referred to as "caudal dogs" The animals of course had no convulsions The results of these operations are given in Table III

A comparison of uniform groups of dogs in Tables I and III receiving the same dose of toxin reveals that on the whole the caudal dogs in Table III lived longer than the intact cord dogs in Table I

Dosage	Survival in Hours	
	Caudal Dogs	Intact Cord Dogs
1/90-1/50	72	120
1/50-1/2	77	49
1 5 -2	53	20

This difference is, we believe, probably due to trauma, a factor which we shall discuss under Experiment 4, and to interference with the blood supply

to the injected area. Even without Experiment 3 we should feel that the constant clonic muscle spasms cannot be an important factor in causing death because a dog that receives into the intact cord $\frac{1}{4}$ LD has convulsions for a matter of hours only while a dog receiving $\frac{1}{100}$ LD or less may have just as violent convulsions for several days before he dies.

TABLE III

CAUDAL PREPARATIONS

All Animals After Operation Had Flaccid Paralysis of the Hind Legs, Six Dogs Injected with Tetanus Toxin Exhibited at Times Some Slight Jerking Movements of the Muscles of the Lower Trunk

A EXPERIMENTAL

Fraction of Lethal Dose Injected	Number of Dogs	Survival in Days		Autopsy and Remarks
		Range	Average	
1/90-1/50	2	3		Normal
1/50-1/20	11	1-7	3.3	One dog had some cystitis
1/20-1/10	11	2-8	3.5	One dog had pneumonia One dog had an extensive subcutaneous infection around the incision
1/10-1/2	8	1-8	2.7	Normal
1/5-2	3	2-3	2.2	Normal
1/40-1/5	8	12-60	23	We feel that in these dogs the point of the needle was between nerve bundles rather than actually inside the cord. Three of these dogs were re-injected and died within 2-4 days

B CONTROLS

Operation but no injection	4	5-51	23	The animal that lived 51 days died of urinary obstruction
Boiled toxin	4	5-20	13	One sacrificed Three died of pneumonia
Tetanus toxin	8	12-60	23	The animals listed on the last line of the first part (A) of this table may be considered as controls for the operation

(IV) *The Lethal Agent Is Not Transported Up the Spinal Cord*—Could it be possible that the tetanus toxin travels from its point of injection in the lumbar cord up the spinal cord to a vital center? We determined to investigate this possibility, although (a) if unchanged toxin travels up the cord one would expect to see evidence (tactile reflex motor tetanus) of its passage and in not one of our dogs has such, or any, evidence presented that toxin, changed or unchanged, has traveled up the cord, and (b) in the absence of true lymphatics in the cord there is no known mechanism* by which toxin

* Toxin injected into the cerebrospinal fluid acts like toxin injected into the blood stream. To rule out the remote possibility that the toxin could travel up the central canal of the cord we tightly ligated the cord outside the dura and injected toxin distal to the point of ligation. Dogs prepared in this manner behaved in every respect like the dogs in Table IVA.

could so travel within the time limits of our experiments, and (c) even those who still adhere to the nerve transport theory* of tetanus, if we understand them correctly, no longer believe that the toxin can travel up within the substance of the cord. Ignoring these arguments, however, we carried out EXPERIMENT 4 (*cf* Expt 3 in our previous report). To rule out the possibility that the toxin travels from its point of injection up the spinal cord to any vital center, we injected less than one lethal dose of tetanus toxin into the motor area of the distal segment of a transected cord. For the sake of brevity these dogs are hereafter usually referred to as "transected cord dogs." These operations are summarized in Table IVA, and the operations on the controls in Table IVD.

It is apparent that, on the whole, these dogs react to the injection of toxin similarly to those in Table I in spite of the fact that the toxin was injected into a cord the physiology of which had been severely altered by transection. Although in Table IVA we have included all dogs in which the injection may not have been entirely within the substance of the cord and have omitted any animals that had any pathologic condition† (in lungs, and so on) which might have hastened death, while in Table IVD (controls) we have included such animals, the average survival of the experimental animals was less than 10 days, of the controls was more than 33 days. It is obvious that the toxin, changed or unchanged, could not have reached the vital centers by traveling up the cord because the cord was not only divided but in almost every dog a piece of cord was excised so that it was quite impossible for the cut ends to come together.

It is interesting to note that in the transected cord dogs the interval between injection and onset of symptoms is approximately the same as in the intact cord dogs.

There are two chief differences between the transected and the intact cord dogs. (a) The transected cord dogs live several (3 to 7) times as long as the intact cord dogs, and (b) some stiffness of the hind limbs is often superimposed on the tactile reflex motor tetanus. These two differences have been observed previously.³ We have frequently observed in our intact cord injections that if the cord is injured (for example, by the rongeur's slipping and bruising the cord) stiffness appears in the affected limbs and life is prolonged for almost as long as if the cord had been transected. We feel that the stiffness is probably due to the injury of the transection, and that the transection so alters the physiology of the cut cord as to prevent the prompt utilization of the toxin, with the result that life is prolonged.

This stiffness of the hind limbs did not appear in all dogs, was very mild in most of the dogs, and in only one or two dogs approached that degree of unyielding rigidity found in local tetanus in which the muscles of the limb are directly injected with toxin. This

* The idea that the toxin is altered is in no way dependent, as will be seen, on any particular theory regarding the route by which the toxin reaches the vital centers.

† In many dogs, experimental and control, the urine at autopsy was very dark and in a few cases obviously bloody.

stiffness could always be abolished temporarily by anesthetizing the animal with ether provided the stiffness had not persisted for so long that permanent contractures had developed. As an explanation of this stiffness it has been suggested that in some way the tetanus toxin enables the cord to recover very rapidly from the period of so-called neural shock after transection, and that the stiffness may be simply ordinary spastic paralysis after transection. All of our control animals, with two or three exceptions, had persistent flaccid paralysis of the hind limbs. Of course, when the toxin is injected proximal to the point of section (see Table IVB) there is no stiffness.

TABLE IV

INJECTION OF TETANUS TOXIN INTO THE TRANSECTED LUMBAR CORD

A FIRST CORD TRANSECTED LATER TOXIN INJECTED DISTAL TO SECTION

All Dogs Had TRMT and Normal Autopsies Unless Otherwise Noted

Num- ber of Dogs	Transec- tion at	Inter- val in Hours	Injec- tion at	Fraction of Lethal Dose Injected	Onset of Symptoms in Hours	Survival in Days		Remarks
						Range	Aver- age	
1	D VI	168	L II	1/2	72	22		
3	D XI	144	L II	1/3-1/6	24-48	5-12	8	
2	D XI	120	L II	1/5	24-48	12-14	13	
1	D XI	96	L II	1/3	24-48	7		
1	D XI	96	L VI	1/3	72	16		Injection into conus
2	D V	72	L III	1/20	24	5-9	7	
4	D VII	0 3	L II	1/2	24	2-11	6	

B FIRST CORD TRANSECTED LATER TOXIN INJECTED PROXIMAL TO SECTION

1	L III	0 7	C VII	1/8	36	3		TRMT of forelimbs
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C FIRST TOXIN INJECTED LATER CORD TRANSECTED PROXIMAL TO INJECTION

All Dogs Had TRMT and Normal Autopsies Unless Otherwise Noted

Num- ber of Dogs	Injec- tion at	Fraction of Lethal Dose Injected	Inter- val in Hours	Transec- tion at	Onset of Symptoms in Hours	Survival in Days		Remarks
						Range	Aver- age	
3	L II	1/2	6	D VI	40	2-6	4	
2	L IV	1/18	5	D VI	None	10-30	20	No symptoms
1	L IV	1/18	4	D VI	24	5 5		
1	L II	1/18	3 5	D VI	96	19		

D CONTROL OPERATIONS

All Dogs Had Flaccid Paralysis

Num- ber of Dogs	Transec- tion at	Inter- val in Hours	Injec- tion at	Material Injected	Survival in Days		Autopsy and Remarks
					Range	Aver- age	
2	D VI	0 3	L II	Needle puncture	28-81	54	Loss of weight
1	D VI	168	L II	Needle puncture	10		

TABLE IV (*Continued*)

Num- ber of Dogs	Transec- tion at	Inter- val in Hours	Injec- tion at	Material Injected	Survival in Days		Autopsy and Remarks
					Range	Aver- age	
1	D VI	0 7	L IV	Boiled toxin	29		
5	D VI- IX	No second operation			30-90	61	
2	D IX- XI	No second operation			1- 4	2	Bloody fluid in peritoneal cavity Bladder dis- tended and full of dark, bloody fluid
2	L V	No second operation			5- 8	6 5	One had extensive infec- tion and was sacrificed in 8 days One had priapism, greatly dis- tended bladder with hemorrhagic cystitis, hydro-ureters, <i>etc</i>
4	D VI and LV	No second operation			5-50	20	
2	L II	No second operation			14-70	42	

Further confirmation of Experiment 4 is found in one dog into whose intact lumbar cord we injected 2,000 guinea-pig LD₅₀'s of tetanus toxin Twenty-four hours later when the dog had marked tactile reflex motor tetanus and was almost dead the entire dorsal cord was removed and implanted through a hollow needle under the skin of the right thigh of one guinea-pig The guinea-pig subsequently developed a slight stiffness of the right hind leg which disappeared in about two weeks, thus demonstrating that in this length (5 cm.) of cord there was not even one guinea-pig lethal dose

In a few dogs toxin was injected into an isolated segment of cord, *ie*, the cord was cut above and below the point of injection The only difference observable between these dogs and those in Table IVA were (a) There was no stiffness in any dog, and (b) fewer muscles were involved in the clonic movements, especially if the two points of section were close to the point of injection

(V) *The Toxin Molecule Is Not Multiplied*—If the toxin molecule is multiplied within the lumbar cord and remains there, death would not ensue because the lumbar cord is not a vital center Apparently some toxin does remain for many hours at the site of injection because we have excised the injected area 19 to 24 hours after injection and put the toxiferous cord into the intact cords of normal dogs, and although some of these recipient dogs developed mild tactile reflex motor tetanus, none died These dogs should have died if the toxin were multiplied to any significant degree and remained at the site of injection

If the toxin molecule is multiplied within the lumbar cord it must be removed from the cord in order to reach a vital center We have demonstrated in Experiment 4 that toxin, whether multiplied or not, whether changed or unchanged, does not travel along the spinal cord or in the cerebrospinal fluid in reaching its site of lethal action Therefore, if the toxin is multiplied it must be removed by the blood and lymphatic systems and distributed throughout the body If amounts sufficient to cause death are so distributed one would

expect to see such signs of general tetanus as muscle rigidity, opisthotonos, and trismus. These signs never appear after the injection of toxin into the cord (cf Expt 5 in our previous report). We have assayed the blood of animals dying from injection of toxin into the cord. No toxin was demonstrable in the blood. We have also injected tetanus antitoxin intravenously into such dogs before the injection of the toxin into the cord and at varying intervals thereafter. If death were due to a multiplication of the toxin molecule as such, one would expect this antitoxin to be used up or destroyed.* But assays fail to show such use or destruction. There is no decrease in the circulating antitoxin in amounts greater than can be accounted for by the limit of error of our assay. Furthermore, assays show that dogs may die with large amounts of free antitoxin circulating in the blood and lymphatic systems (see Experiments 5 and 6 below).

Dr R. B. Hyde very kindly tested on chicken embryos the possibility that toxin alone or toxin-bearing areas of cord produce a transmissible virus effect. These experiments were negative.

Since we have shown that (a) the principal factor causing death is not the metabolic changes consequent to the constant muscular spasms, and that (b) the blood and lymphatic systems are the only remaining pathways by which the lethal agent can reach a vital center, and that (c) the tetanus toxin itself is not multiplied, it seems permissible to suggest that tetanus toxin in the spinal cord is changed into a new lethal agent that is absorbed by the blood stream and carried to some vital center.

(VI) *The Effect of Tetanus Antitoxin*—Abel and Chalian¹² showed that after the intravenous injection of one or more lethal doses of tetanus toxin, the administration of even large amounts of antitetanic serum fails to save life if before the serum is given the animal has clearly evident symptoms of a descending tetanus and has fixed in his tissues one or more lethal doses of the toxin. They showed further that even though the animal's tissues had fixed many lethal doses of the toxin, the antitetanic serum could save life if given not later than at a certain stage of the incubation period before the appearance of symptoms of general tetanus. We thought it would be interesting to study the effect of antitoxin on tactile reflex motor tetanus. EXPERIMENTS 5 and 6. Our injections of tetanus toxin into the lumbar cord and into the medulla were made as usual. The dogs received then antitoxin *per venam*. In Table V we give the results of injecting antitoxin before and after the injection of toxin into the intact lumbar cord, in Table VI the results of injecting antitoxin before and after the injection of toxin into the medulla.

We have expressed the amount of tetanus antitoxin as so many "neutralizing doses of TAT." By one neutralizing dose of antitoxin we mean that amount of antitoxin which is just enough to protect the animal (i.e., prevent death) against a given amount of toxin when both are injected *per venam*, the toxin immediately after the antitoxin. In such experiments one American unit of antitoxin per kilogram will prevent death in an animal which receives 6500 guinea-pig LD 50's of toxin per kilogram. Hence in the tables each "neutralizing dose" represents one unit of antitoxin for each 6500 guinea pig LD 50's of

* See Experiments 5 and 6 for a note on the absence of any blood-brain barrier for tetanus antitoxin.

toxin or for each 13.5 dog lethal dose. When we say we gave 100 or 500 neutralizing doses of antitoxin we mean that we injected 100 to 500 times as much antitoxin as would have been necessary to protect against the toxin injected had both been given intravenously, the toxin immediately after the antitoxin.

In a subsequent paper we shall deal more extensively with the protecting value of antitoxin against toxin introduced by various routes. We shall demonstrate that although the protecting value is less when the toxin is introduced intramuscularly, subcutaneously, or intracutaneously than when toxin is given intravenously, the only route by which the difference is really remarkable is when the toxin is injected directly into the lumbar cord or medulla.

TABLE V

TETANUS TOXIN IN INTACT LUMBAR CORD, TETANUS ANTITOXIN INTRAVENOUSLY

All Autopsies Normal

A ANTITOXIN BEFORE TOXIN

Dog Number	Fraction of Lethal Dose Injected	Neutralizing Doses of Antitoxin	Interval in Hours Between Injection of TAT and of Toxin	Symptoms Before Injection of TAT	Symptoms After TAT	Survival in Days	Remarks
437	1/2	800	0.5		Yes	2-	No prolongation of life
560	1/2	1,600	0.5		Yes	4	Life prolonged
438	1/2	4,000	0.5		No	Indefinite	Completely protected
439	1/2	8,000	0.5		No	Indefinite	

All Autopsies Normal

B TOXIN BEFORE ANTITOXIN

81	1/12	2,400	0.5	No	Yes	2-	No prolongation of life
80	1/12	5,600	0.5	No	Yes	8	
403	5.0	400	3.0	No	Yes	1	Life may be prolonged, but usually is not prolonged
440	1/2	800	6.0	No	Yes	5	
655	1/2	800	6.0	No	Yes	2.2	
443	1/2	4,000	6.0	No	Yes	1	
442	1/2	8,000	6.0	No	No	Indefinite	Symptoms may appear, but life is spared
441	1/2	40,000	6.0	No	Yes	Indefinite	
410	3.0	560	10.5	Yes	Yes	1-	No protection
411	3.0	800	10.5	Yes	Yes	1-	
594	1.5	1,000,000	13.5	Yes	Yes	1-	
675	1/20	8,000,000	115.0	Yes	Yes	5.8	

If we assume that the lethal dose for intact cord and for medulla injection is 1/100 and 1/500 of the intravenous lethal dose, it is apparent that, in general, our results parallel those of Abel and Chalian¹² in whose experiments the toxin was injected intravenously. After the appearance of definite symptoms even relatively enormous doses of antitoxin do not affect the outcome. The longer the interval before the injection of antitoxin, the larger must be the amount of antitoxin given in order to prolong or to save life.

A very striking feature of these experiments is that even when the anti-

toxin is given *before* the toxin, relatively large amounts of antitoxin are required to save life or even to prevent the appearance of symptoms, and this is especially true when the toxin is injected into the medulla. Some readers may resurrect the theory that there is a barrier which prevents the antitoxin in the blood from reaching the toxin in the cord. But obviously no such barrier exists, because if sufficiently large doses of antitoxin are given before the onset of symptoms the animals develop no symptoms and do not die. The antitoxin must, therefore, have migrated from the blood to the substance of the cord.* It may be that the concentration of antitoxin brought by the blood to the injected area is too small to neutralize quickly the admittedly high concentration of toxin injected directly.

TABLE VI

TETANUS TOXIN IN MEDULLA, TETANUS ANTITOXIN INTRAVENOUSLY

All Dogs Received 1/10 Lethal Dose of Toxin Autopsies Normal Unless Noted

A ANTITOXIN BEFORE TOXIN

No of Dogs	Neutralizing Doses of Antitoxin	Interval in Hours Between Injections of TAT and of Toxin	Symptoms Before Injection of TAT	Symptoms After TAT	Survival in Days	Remarks
14	8-8,000	0 25-0 5		Yes	1 6	No prolongation of life
1	10,000	0 25-0 5		Yes	4 0	Symptoms present Life prolonged
2	16,000	0 25-0 5		Yes	4 3	
1	32,000	0 25-0 5		Yes	6 0	
2	40,000	0 25-0 5		Yes	12 0	
1	64,000	0 25-0 5		No	Indefinite	Mild symptoms generally appear but life is usually saved
1	80,000	0 25-0 5		Yes	Indefinite	
1	92,000	0 25-0 5		Yes	20 0	
2	160,000	0 25-0 5		Yes	Indefinite	
1	400,000	0 25-0 5		No	Indefinite	Completely protected
1	800,000	0 25-0 5		No	Indefinite	

B TOXIN BEFORE ANTITOXIN

1	400,000	6 0	No	Yes	2-	No prolongation of life
1	800,000	5 0	No	Yes	Indefinite	Symptoms may appear but life is spared
1	400,000	18 0	Yes	Yes	1 7	No protection
1	800,000	18 0	Yes	Yes	1 7	

There is the added factor of fixation of the toxin. Although no one knows what happens to tetanus toxin when it undergoes that change which is generally termed "fixation" (*i.e.*, the toxin can no longer be recovered in a form recognizable by our present methods of assay), it appears likely from the work of Abel and Chalian, although they do not say so, that there are two stages of fixation (a) The fixed toxin can still be rendered innocuous by excessive amounts of antitoxin, and (b) the fixed toxin can no longer be neutralized by antitoxin although at this time the toxin may not yet have begun to cause recognizable symptoms but will inevitably do so. It may be that the neurones

* For further remarks on the absence of a blood-brain barrier see the papers by Doctor Abel and his coworkers, especially Paper VIII in his series¹²

into which we inject the toxin fix the toxin so rapidly into stage (b) that the antitoxin has no chance to neutralize it. However, Experiment 6A seems to indicate (1) That, on the contrary, the neurones, although exposed to a high concentration of toxin, fix it into stage (b) no more rapidly than when toxin is injected intravenously, and (2) that by intravenous injection antitoxin, unless in very large amounts, is not brought in sufficient concentration to the point of deposit of the toxin to neutralize the toxin. In the present state of our ignorance it is futile to speculate further upon the question of whether or not and how the toxin may be fixed.

The important fact is that, regardless of how the toxin may be fixed, it is necessary to administer large doses of antitoxin before the onset of symptoms, or earlier, if the animal is to be saved. That this holds true, even when the antitoxin is injected directly into the cord, is shown by Experiment 6A, in which toxin was injected into the medulla and at varying intervals thereafter antitoxin was injected into the same spot, as nearly as we could judge, into which the toxin had been injected.*

TABLE VI A

TETANUS TOXIN IN MEDULLA, TETANUS ANTITOXIN IN MEDULLA LATER

Dog Number	Interval Frac- tion of Lethal Dose In- jected	Interval in Hours Between Injection of Toxin and of TAT	Neutral- izing Doses of Anti- toxin	Symptoms Before Injection of TAT	Symptoms After Injection of TAT	Survival in Days	Remarks
362	1/25	5 5	800	No	No	Indefinite	Completely protected
363	1/25	5 5	800	No	No	Indefinite	
365	1/25	11	800	Question- able	Yes	6 5	
366	1/40	20	1,600	Question- able	Yes	5 0	Life is pro- longed
364	1/25	11	800	Yes	Yes	2 0	
367	1/40	17 5	1,600	Yes	Yes	2 4	No protection
356	1/10	18	3,200	Yes	Yes	1 5	
357	1/10	18	3,200	Yes	Yes	1 5	

Unfortunately, the doses of toxin used here were not the same as those injected into the dogs of Table VI, and, consequently, we cannot directly contrast the two entire groups of animals. It is obvious that once symptoms appeared no lives were saved by antitoxin, but we did not, in these dogs, use very large amounts of antitoxin for fear that too much fluid injected into the medulla would, by its bulk, cause disturbances leading to death.

It is apparent, however, that the intravenous injection of the antitetanic serum is far less efficient than the method of administering the antitoxin used in Experiment 6A, with the latter method 800 neutralizing doses given five hours after the injection of toxin are sufficient to confer full protection, with the former method, in order even to approximate the same degree of protection, 800,000 neutralizing doses of antitoxin must be given, if administered five

* This experiment was suggested and carried out by Dr. George G. Hogeboom.

hours after the injection of toxin, or 64,000 neutralizing doses if given *before* the injection of toxin

(VII) *Excision of Cord Injected With Tetanus Toxin*—In going over our records we noticed that once or twice when we had excised an injected cord for transplantation into another dog we did not, as was our usual practice, sacrifice the dog from which the cord had been taken. Our technician had recorded that these dogs continued to show tactile reflex motor tetanus and died fairly soon.

EXPERIMENT 7—As this seemed unlikely, and as the removal of the injected area was another way of doing what we had tried to do in our antitoxin experiments (*i e*, prevent death), we injected toxin into the intact lumbar cord and, at varying intervals thereafter, we excised the injected area. The needle puncture was identified and the proximal level of section, ascertained by measuring the shrunken cord after excision, was always at least 1 cm above the puncture and in every case we removed at least 2 cm of cord. Our results are given in Table VII.

TABLE VII

EXCISION OF INJECTED AREA OF LUMBAR CORD

Num- ber of Dogs	Site of Injec- tion	Frac- tion of Lethal Dose In- jected	Onset of Symp- toms in Hours	Symp- toms Present Before Excision	Interval in Hours Between Injection and Ex- cision	Length of Cord Ex- cised in Cm	Symp- toms Present After Excision	Survival in Days	
								Range	Aver- age
2	L I	1/40	48	TRMT	48	?	TRMT	2-10	7
1	L II	1/10		None	19	?	Flaccid	11	
1	L II	1/10		None	22	9 0	Flaccid	21*	
4	L II	1/10	44	TRMT	48	9 0	Flaccid	5-11	7 5
1	L II	1/10	20	TRMT	Control—cord not excised			1	5
1	L II	1/2		None	29	2 6	? Reflexes hyper- active	37	
2	L II	1/2	24	Mild TRMT	25	1 6	TRMT	4-5+	5
1	L II	1/2	24	TRMT	47	1 8	TRMT	3	6
1	L II	1/2	16	TRMT	18	?	TRMT	1	6
1	L II	1/2	16	Mild TRMT	18	?	TRMT	2	6
2	L II	Control—no toxin			28	1 7	Flaccid	14-70*	42

* Sacrificed

We find if we excise only a small area of cord, that here again we must act before symptoms appear in order to save or to prolong life. If we act after the appearance of symptoms the animals usually continue to jerk and die sooner than the uninjected operative controls. If we excise a large area of cord after the onset of symptoms, life is prolonged and there are no symptoms after the excision of the cord.

(VIII) *Cross-Circulation Experiments*—When the possibility of the alteration of tetanus toxin first occurred to us, we tried to demonstrate such alteration in a positive manner by injecting various amounts of toxin into the cord of dogs and then removing the toxiferous area and injecting that into the thigh muscles, peritoneal cavity, cord, or medulla of normal dogs in the hope that the normal dogs would die. We ignored the probability that the blood stream would remove any lethal agent in the cord of the donor dog and the possibility that, in the process of transferring the injected area from donor to recipient, exposure to air might destroy any lethal agent by oxidation. Of 63 dogs receiving such "transplants," 57 lived more than six days. Of the six dogs dying in less than six days, only two or three had no pathologic condition to account for death. We also tried incubating toxiferous cord *in vitro*. Here there was less chance of oxidizing a lethal agent, but on the other hand the cord was dead. These unnatural experiments also were negative.

As it became increasingly probable, however, that the results of our cord injections could be explained only on the basis (a) that the tetanus toxin is gradually altered, and (b) that the altered substance is not stored in the cord but (c) is taken up by the blood stream as it is formed, we cast about for another method of demonstrating such alteration. If the blood stream carries to the vital centers an altered lethal product of tetanus toxin, by transferring the blood of the affected dog into a normal dog it should be possible to kill the normal dog by means of this lethal agent, provided that there is enough of the lethal agent in the blood stream of the affected dog to kill both this dog and the normal dog. The most thorough and physiologic method of so transferring the blood is to unite the circulations of the two dogs, a procedure which we¹³ had often performed previously in this laboratory, which we knew to be quite harmless although continued for several days, and which ensured a thorough intermingling of all the elements in the blood of the two dogs.*

EXPERIMENT 8—The cross-circulation of normal dogs with dogs dying as a result of the injection of tetanus toxin into the medulla spinalis or oblongata or into the blood stream.

We employed our usual technic in injecting tetanus or diphtheria toxin into the lumbar cord, into the medulla, or into the veins of what we called the "donor dogs", *i.e.*, they manufacture and donate the altered toxic agent to the normal or "recipient dogs". At varying intervals after the injection of toxin we united the circulations of the two dogs. A modified Carrel technic¹³ was used to join by end-to-end anastomosis the common carotid artery of the donor dog to the external jugular vein of the recipient dog, and *vice versa*. At least 15 minutes before the anastomosis was opened, each recipient dog received enough tetanus antitoxin to neutralize many times the amount of tetanus toxin injected into the donor dog. The dogs were kept on the operating table throughout the experiment. The

* In a long continued cross-circulation experiment the blood streams of both animals will eventually have equal concentrations of the formed and chemical elements in the blood provided one animal is not receiving into its blood stream a steady supply of some element. But if, for example, one animal is receiving glucose solution *per venam* or is absorbing glucose from the stomach, the sugar content of his blood will remain persistently higher than that of the other animal not receiving such a supply. This should be kept in mind in reading the accounts of the following experiments.¹⁴

anastomoses and other exposed tissues were kept covered with cotton pads saturated with warm normal saline. The anastomoses were inspected every 30 minutes to make sure they were functioning properly. Very rarely a small clot would be found partially obstructing one anastomosis, these were promptly dislodged. The dogs operated upon under nembutal anesthesia were given additional small doses of nembutal whenever they became restless. Fluids were given, usually by mouth.

PROTOCOL OF TYPICAL EXPERIMENT

<i>Donor Dog No 448</i> Tan, adult, female, 6 o Kg		<i>Recipient Dog No 430</i> Gray	
October 24, 1938		police puppy, 6 mos, female,	
5 45 P M	Received 15 LD tetanus toxin into intact cord at L II	4 35 Kg	
October 25, 1938			
9 30 P M	TRMT T 105 8°F		
10 45	T 106°F	T 101 6°F	
11 05	Received 0.16 Gm nembutal intraperitoneally	Received 0.13 Gm nembutal intraperitoneally	
11 30	Cross-circulation operation begun T 104 6°F		
12 00 Noon		Received 1 cc TAT <i>per venam</i> (1,400 neutralizing doses)	
12 35 P M	Anastomosis opened		
1 00	T 104 2°F, P 180, R 20— Marked TRMT	T 102 3°F, P 176, R 20	
2 00	T 107 2°F, P 240, R 18—Restless	T 104 6°F, P 210, R 28	
2 20	Received 0.025 Gm nembutal i p		
2 30	T 108 4°F, P 240, R 140	T 104 5°F, P 200, R 176	
4 00	T 109 8°F, P 240, R 80	T 106 4°F, P 240, R 124	
4 25	Respirations 88, irregular, and failing	R 12	
4 28	Anastomosis closed Took sample of blood for hematocrit determination—42	Anastomosis closed Took sample of blood for hematocrit—41	
4 35	Respirations ceased		
4 37	Heart stopped	Respirations ceased	
4 42	Autopsy normal	Heart stopped	
		Autopsy normal No evidence of blood loss or shock	

Over 40 pairs of dogs were so cross-circulated. Tables VIII to XII summarize these operations. In Table VIIIA the cross-circulation was ended 2 to 30 hours before the death of the donor. Of the six recipients in Table VIIIA only one died. That even one dog died is surprising, because one could not expect the concentration of the altered substance to reach its maximum until fairly near the death of the donor dog. In the next series (Table VIIIB) we continued the cross-circulation until within a short time of death.

Of the 14 recipients in Table VIIIB, only two lived, a result which exceeded our expectations. We next sought to show that the mere fact of being cross-circulated with a dying dog would not suffice to kill the recipient. We killed donor dogs by a medullary necrosis consequent to the injection of diphtheria toxin into the medulla (Table IX).

TETANUS

TABLE VIII

CROSS-CIRCULATION TETANUS TOXIN IN LUMBAR CORD OF DONOR DOG

Cross-Circulation Under Nembutal Anesthesia

A CROSS-CIRCULATION ENDED 2 TO 30 HOURS BEFORE DEATH OF DONOR

Number of Donor Dog	Combined Weight in Kg of Both Dogs	Lethal Doses of Tetanus Toxin Received by Donor	Neutralizing Doses of TAT Received by Recipient	Interval in Hours Between Injection of Tetanus Toxin and Beginning of Cross-Circulation	Length in Hours of Period of Cross-Circulation	Total Nembutal Given in Grams	Period of Survival of Donor After Cross-Circulation Ended	Period of Survival of Recipient After Cross-Circulation Ended	Fate of Recipient	Remarks
337	15 7	0 5	5 600	4 5	7 0	0 93	30 hrs		Lived	
378	11 2	5 0	800	6 7	1 5	0 36	4 2 hrs		Lived	
388	12 4	0 3	9,600	25 5	5 5	0 43	6 hrs		Lived	
399	9 4	0 5	4 000	23 0	16 0	0 80	13 hrs	24 hrs	Died	
402	12 8	5 0	400	3 5	11 0	0 60	14 hrs		Lived	
426	8 6	1 5	1 000	15 3	6 0	0 40	2 hrs		Lived	

B CROSS-CIRCULATION ENDED WITHIN 2 HOURS OF DONOR'S DEATH

371	12 1	0 05	56 000	49 0	8 3	0 52	0	0	Died	Recipient weighed 12 to 45% less than donor
391	12 2	0 5	6 000	18 5	27 0	0 84	0	7 mins	Died	
417	7 5	1 5	1 400	14 0	4 0	0 33	1 5 hrs	27 hrs	Died	
418	13 2	1 5	880	15 5	5 0	0 48	2 5 mins	30 mins	Died	
447	10 1	1 5	1 440	17 0	7 5	0 38	4 mins	2 mins	Died*	
448	10 4	1 5	1 400	19 0	4 0	0 32	7 mins	9 mins	Died	Weights equal
465	12 1	1 5	2 400	15 5	4 0	0 41	3 mins		Lived	
605	25 2	1 5	368	13 0	4 3	0 75	3 mins	18 hrs	Died	
395	10 8	0 5	4 000	21 5	20 0	0 51	5 mins	5 5 hrs	Died	
398	14 1	0 5	3 200	21 0	5 0	0 56	10 mins	0	Died*	
424	9 9	1 5	1 400	14 2	5 3	0 35	2 mins	2 5 hrs	Died	Recipient weighed 20 to 35% more than donor
434	12 8	1 5	1 200	17 5	3 7	0 43	5 mins		Lived	
433	6 8	1 5	2 480	13 5	5 0	0 20	8 mins	4 mins	Died*	
466	9 6	1 5	3,600	14 0	24 0	0 68	1 min	6 mins	Died	

* Dogs No 447 398 and 433 The recipient died before the donor

TABLE IX

CROSS-CIRCULATION CONTROL DIPHTHERIA TOXIN IN MEDULLA OF DONOR DOG

Cross-Circulation Under Nembutal Anesthesia

Number of Donor Dog	Combined Weight in Kg of Both Dogs	Diphtheria Toxin in Cc Received by Donor Dog	Interval in Hours Between Injection of Toxin and Beginning of Cross-Circulation	Length in Hours of Period of Cross-Circulation	Total Nembutal Given in Grams	Period of Survival of Donor Dog After Cross-Circulation Ended	Fate of Recipient
459	8 9	008	17 5	0 5	0 2	0	Lived
517	11 5	012	2 5	1 5	0 33	4 mins	Lived
515	12 0	008	2 0	21 2	1 6	5 mins	Lived
520	12 9	010	2 5	13 5	9 97	4 mins	Lived
565	11 7	011	2 0	8 5	0 70	0	Lived
567	12 2	011	2 7	5 8	0 85	0	Lived

Since none of the recipients in Table IX died we felt that this procedure was an adequate control for the fact of death

VARIOUS OTHER CONTROL PROCEDURES ON CROSS-CIRCULATED DOGS

(A) *Adequacy of Cross-Circulation* In many dogs complete blood counts and hematocrit determinations were made during the course of the cross-circulation and after. The values for the donor and for the recipient were the same after the first five to ten minutes of cross-circulation.

(B) *Blood Pressure and Blood Volume* In no case was there any pallor or other gross evidence of blood loss from one dog into the other. When both donor and recipient died within a few minutes of each other no gross differences could be detected in color or in filling of the vascular system. Dogs dying as the result of the injection of 15 lethal doses of toxin in the lumbar cord maintain normal blood pressure until about 20 to 30 minutes before death. At this time, the pressure falls gradually to 50 or 60 Mm of mercury. During the last five minutes before death the pressure may fall to 20 Mm. Of course, after respiration ceases the pressure gradually drops to zero as the heart fails. Such a low pressure in the donor is not, in itself, sufficient to cause the death of the recipient, for the blood pressure falls similarly in dogs dying as the result of the injection of diphtheria toxin in the medulla oblongata without causing the recipients to die. During the cross-circulation of normal dogs¹⁴ significant, but never fatal loss (25 to 30 per cent), of blood volume was suffered only by those dogs whose size and original blood volume were about twice as large as that of the dogs with which they were cross-circulated. The blood lost by the larger dogs caused a proportional increase in the blood volumes of the smaller dogs. This blood loss occurred in spite of the fact that the blood pressures of the larger dogs during the period of cross-circulation were only half as high as those of the smaller dogs. In our cross-circulation experiments with dogs that had received tetanus toxin in the lumbar cord or intravenously, 61 per cent of the donors weighed 10 to 50 per cent more than the recipients, 22 per cent were equal in weight, and in only 16 per cent did the donors weigh less than the recipients. In a majority of these experiments, therefore, if any blood were lost from one dog to the other it should have been lost by the donor to the recipient. To make sure that the recipient had plenty of blood we occasionally permitted the donor to pump blood into the recipient after the donor had stopped breathing. This procedure did not save the lives of the recipients.

(C) *Adequacy of Antitoxin* Assays made of the antitoxin content of the blood of dying recipient dogs agreed with the known amount of antitoxin injected before cross-circulation. For example, one dog (No. 466) after 24 hours of cross-circulation still had 18 units of tetanus antitoxin in every cubic centimeter of serum.

(D) *Blood Chemistry* Chemical studies on the blood revealed that the most persistent and striking change was a lowering of the blood sugar content. This change, however, appeared as often when the recipient lived as when he died. One recipient died with a blood sugar content of 93 mg per cent. Four recipients died, although given large quantities of glucose by mouth and by vein during the period of cross-circulation.

We next cross-circulated dogs dying from an injection of tetanus toxin into the medulla oblongata (cf. Experiment 2).

None of the recipients in Table X died. This result made us wonder whether it could be possible that since the tetanus toxin is injected into or close by the respiratory center, its lethal agent does not have to be carried by the blood stream to a vital center, but rather the toxin is changed and has its lethal effect where it is injected, and death occurs before any large amount of the changed substance is present in the blood stream. We shall return to this point in the Discussion.

TABLE X

CROSS-CIRCULATION				TETANUS TOXIN IN MEDULLA OF DONOR DOG				
Number of Donor Dog	Combined Weight in Kg of Both Dogs	Lethal Doses of Tetanus Toxin Received by Donor	Neutralizing Doses of TAT Received by Recipient	Interval in Hours Between Injection of Tetanus Toxin and Beginning of Cross-Circulation	Length in Hours of Period of Cross-Circulation	Total Nembutal Given in Grams	Period of Survival of Donor After Cross-Circulation Ended	Fate of Recipient
383	10 7	0 07	560	10 0	3 0	0 37	7 hrs	Lived
576	10 6	3 0	400	2 0	1 5	0 37	0	Lived
589	10 5	2 5	320	2 0	10 0	Ether	0	Lived
580	13 3	2 5	376	3 2	7 0	Ether	0	Lived
584	14 2	3 0	360	2 5	9 1	Ether	0	Lived

It will be noted in Table X that in two instances the cross-circulation was carried out under nembutal anesthesia, and in three instances under ether anesthesia. In our previous cross-circulations we had always used nembutal because the position of the dogs' heads made it difficult to administer ether. In the case, however, of dogs that had, some hours earlier, received tetanus toxin in the medulla we found that the injection of our usual dose of nembutal in preparation for operation would very frequently be followed within 15 to 20 minutes by the death of the animal, whereas similar animals not receiving nembutal would live many hours longer, consequently we used ether as the anesthetic for the last three operations in Table X. But this unexpected complication made us wonder whether nembutal could be responsible for the death of the recipients in the earlier cross-circulation experiments. We, therefore, repeated the series in Table VIIIB, using ether for anesthesia instead of nembutal.

TABLE XI

CROSS-CIRCULATION TETANUS TOXIN IN LUMBAR CORD OF DONOR DOG

Cross-Circulation Under Ether Anesthesia

Number of Donor Dog	Combined Weight in Kg of Both Dogs	Lethal Doses of Tetanus Toxin Received by Donor	Neutralizing Doses of TAT Received by Recipient	Interval in Hours Between Injection of Tetanus Toxin and Beginning of Cross-Circulation	Length in Hours of Period of Cross-Circulation	Period of Survival of Donor After Cross-Circulation Ended	Period of Survival of Recipient After Cross-Circulation Ended	Fate of Recipient	Remarks
592	13 3	1 5	368	14 0	4 9	0	10 mins	Died	Recipient weighed 18 to 34 per cent less than donor Weights equal
593	12 1	1 5	368	12 0	7 0	1 min		Lived	
601	10 3	1 5	368	14 3	8 7	3 mins		Lived	
623	11 5	1 5	368	14 5	6 5	1 min	5 mins	Died	
600	14 9	1 5	368	13 0	5 7	2 mins		Lived	Recipient weighed 24 to 53 per cent more than donor
609	14 0	1 5	736	13 0	4 3	3 mins		Lived	
610	16 5	1 5	736	14 2	12 8	3 mins		Lived	

Of the seven recipients in Table XI, only two died. This seemed to indicate that probably nembutal *had* played some part in the death of the earlier

recipients But when we compared the amounts of nembutal received by recipients that died with the amounts received by recipients that lived, we could not find that the dying recipients received even as much nembutal as the recipients that lived

Cross-Circulation With		Amount of Nembutal Received in Gm Per Kilo Per Hour
Tetanus donor	13 recipients died*	0 0085 Gm
Tetanus donor	7 recipients lived	0 0106 Gm
Diphtheria donor	6 recipients lived	0 013 Gm

* These 13 dogs died from 15 to 20 hours after receiving their last doses of nembutal The average time was 7.3 hours, six dogs died in less than five hours, two of these in less than three hours

It was obvious that the rôle, if any, played by nembutal in causing the death of the recipient was not a major one It occurred to us that the depressive effect of nembutal on an already poisoned respiratory center might be sufficient to cause death when neither the nembutal nor the poison was present in sufficient amounts alone to cause death This seemed to be a possible explanation of our results To test this theory, Dr Jonas Friedenwald suggested that we carry out our usual cross-circulation experiment under ether anesthesia and that we give a small and unquestionably safe dose of nembutal to the recipient immediately after cessation of the cross-circulation

TABLE XII

CROSS-CIRCULATION EFFECT ON RECIPIENT OF NEMBUTAL GIVEN AFTER CROSS-CIRCULATION ENDED

Cross-Circulation Operation Performed Under Ether Anesthesia

A TETANUS TOXIN IN LUMBAR CORD OF DONOR

Number of Donor Dog	Combined Weight in Kg of Both Dogs	Lethal Doses of Tetanus Toxin Received by Donor	Neutralizing Doses of TAT Received by Recipient	Interval in Hours Between Injection of Tetanus Toxin and Beginning of Cross-Circulation	Length in Hours of Period of Cross-Circulation	Total Nembutal Given in Grams	Period of Survival of Donor After Cross-Circulation Ended	Period of Survival of Recipient After Cross-Circulation Ended	Fate of Recipient	Remarks
624	16 6	1 5	368	13 0	3 1	0 23	1 min	15 mins	Died	Usual dose of nembutal

B TETANUS TOXIN IN VEIN OF DONOR

672	14 5	100	288	40 0	2 7	0 11	0		Lived	Two thirds of usual dose of nembutal
704	13 6	100	400	27 0	11 0	0 13	0	45 mins	Died	"
705	10 2	100	480	25 0	12 4	0 11	0	1 hr	Died	"

Of the four dogs in Table XII, only one survived, a result which tends to substantiate our explanation In view of this and of the extensive clinical use of avertin and other hypnotics we thought it wise to examine the effect of nembutal and avertin on the course of general tetanus in dogs

(IX) *The Effect of Hypnotics on the Survival of Dogs With Tetanus* —
EXPERIMENT 9—Twenty-one dogs received *per venam* 15 dog lethal doses of tetanus toxin. As soon as the dogs showed such severe symptoms of general tetanus that they could no longer stand or eat, they were divided, in rotation, into three groups. Group A received repeated but nonlethal doses of avertin, sufficient in amount to stop convulsions for the course of the experiment. Group B received similar doses of nembutal. Group C received no treatment. Table XIII gives the results of this experiment.

TABLE XIII

THE EFFECT OF AVERTIN AND NEMBUTAL ON THE SURVIVAL OF DOGS WITH
GENERAL TETANUS

All Dogs Received, Per Venam, 15 Lethal Doses of Tetanus Toxin

Hypnotic Used	Dog Number	Interval in Days Between Injec- tion of Toxin and Onset of Severe Symptoms	Avertin or Nembutal in Grams per Cc per Hour	Survival in Days After Onset of Severe Symptoms	Survival in Days After Injection of Toxin
AVERTIN	681	4 42	044	1 88	6 30
	680	5 00	043	1 88	6 90
	682	5 10	054	1 19	6 29
	686	5 10	040	1 94	7 04
	677	5 67	100	0 43	6 10
	690	6 65	020	2 92	9 57
	683	6 82	212	0 04	6 86
	Average	5 54	070	1 47	7 01
NEMBUTAL	697	3 66	0050	1 64	5 30
	699	4 58	0043	0 42	5 00
	692	5 07	0025	3 10	8 17
	685	5 58	0020	1 80	7 38
	700	5 58	0040	3 70	9 28
	693	6 20	0090	1 25	7 45
	Average	5 11	0031	1 99	7 10
CONTROL	696	2 80	None	2 37	5 17
	689	4 00	"	3 50	7 50
	684	4 83	"	0 08	4 91
	687	5 00	"	3 12	8 12
	698	5 05	"	2 41	7 46
	695	5 07	"	4 33	9 40
	679	5 67	"	6 76	12 43
	694	7 63	"	4 54	12 17
	Average	5 01		3 39	8 41

It will be seen that the controls lived almost a day and a half longer than the dogs receiving avertin and nembutal, and that the controls, after they could no longer stand, lived almost two days longer than the dogs receiving avertin and almost one and a half days longer than the dogs receiving nembutal. If the abolition of convulsions has any effect in prolonging life it is obvious

that this effect should be more noticeable in the absence of any nourishment after the onset of severe symptoms. We conclude, therefore, that under the conditions of this experiment the administration of avertin or of nembutal is not only of no benefit but may actually be harmful.

The dose of avertin received by some of the animals was admittedly large, but on the other hand the dose of nembutal was known to be quite safe. For example, we have given, with no ill effects, to normal dogs doses of nembutal 33 per cent greater and for a 50 per cent longer period than the average of the experimental animals in Table XII. In Experiment 12, we were interested in giving enough of the hypnotic to stop convulsions and to confer some degree of relaxation. Although it is possible that in some instances the survival period of the dogs receiving avertin may have been shortened by toxic action of the avertin, it is obvious that the survival period was also shortened in those animals receiving doses of nembutal known to be harmless.

Discussion—The injection of less than one lethal dose of tetanus toxin into a nonvital area of the central nervous system invariably kills dogs, cats, rabbits, guinea-pigs, and monkeys. As little as 1/400 of a lethal dose placed in the lumbar cord of a dog has produced symptoms and death. The injection of less than a lethal dose of toxin into organs other than the central nervous system is never fatal. This peculiar phenomenon calls for an explanation.

We have attempted to show that metabolic changes consequent to the constant muscular spasms are not the principal factor in causing death. In the absence of muscular spasms (Experiment 3) life is prolonged to some extent but death ensues fairly promptly. It seems likely that this prolongation of life is due to the impaired circulation of the cord and not to the abolition of convulsive movement. Furthermore, when toxin is injected into the intact cord, those animals receiving relatively small doses have a far longer period of violent convulsions and survive longer than those animals receiving relatively large doses. However, the muscular spasms in our intact cord dogs may to some degree hasten death. Studies of the blood chemistry of dying dogs have revealed no changes which could account for death.

All these facts led us to the conclusion that a lethal agent must be carried from the point of injection of toxin in the lumbar cord to some vital center. By transecting and by ligating the injected cord we have shown that the lethal agent does not pass up the spinal canal in the cerebrospinal fluid or within the substance of the cord itself.

We have explored the possibility that the small amount of toxin we inject is in some way multiplied to an amount sufficient to cause death. We have been able to show that such multiplication of the tetanus toxin molecule does not occur. Transplant experiments and assays show that the toxin is not multiplied and retained in the lumbar cord. Furthermore, the blood and lymphatic systems are the only remaining pathways by which the lethal agent can reach a vital center. If the toxin were multiplied and absorbed by the blood stream in amounts sufficient to cause death, there would be present such signs of general tetanus as trismus, opisthotonos, and muscular rigidity. These signs never appear in animals dying from injection of toxin into the cord.

Finally, death still occurs even though the blood and lymph contain large amounts of antitetanic serum throughout the entire course of the experiment. Obviously, if the toxin were multiplied and absorbed into the blood stream it would be neutralized by the antitoxin.

We therefore suggest (a) that tetanus toxin in the spinal cord is altered into a new lethal agent that is absorbed by the blood stream and is carried to some vital center where it has its lethal effect, and (b) that this new lethal agent is not neutralized by tetanus antitoxin.

The results of the injection of toxin into the medulla oblongata provide some additional evidence of this alteration, for even when toxin is injected into or close by vital centers in the medulla there is still a period of incubation and a period between the onset of symptoms and death. If death is due to the effect of *unchanged* toxin on the vital centers, death should come very much sooner than it does when toxin is placed in the medulla. Dogs receiving a solution of morphine sulphate in the medulla act very differently from the tetanus dogs. Within 15 minutes after the injection of morphine the respiration is depressed and signs of medullary irritation are present. These dogs have disturbances of deglutition which resemble the pharyngeal spasms of the tetanus dogs. The important fact is that after the injection of morphine these disturbances come on very much more quickly than after the injection of tetanus toxin.

The suggestion has been made by previous workers that tetanus toxin is altered into a different substance. Courmont and Doyon¹⁵ thought that possibly the central nervous system symptoms of tetanus do not appear until the toxin has been changed into a strychnine-like body. Pohl, according to his assistant Zupnik,¹⁶ said that tetanus toxin in striated muscle may be changed into a second body which causes death. Recently Zuger and Friedmann¹⁷ have offered this same possibility as one explanation of some of their experiments. The earlier suggestions, however, having little experimental evidence to support them, went unheeded.

Alteration such as we have described would explain the experimental results of Abel and Chalian mentioned above and would also explain the puzzling clinical finding that the use of tetanus antitoxin has not appreciably lowered the mortality rate of those patients who do not receive antitoxin until after the appearance of the central nervous system symptoms of tetanus.

We wish to emphasize the fact that the experimental work so far reported should by no means be interpreted as making unnecessary the use of tetanus antitoxin as a therapeutic agent in clinical tetanus. It is true that in dogs with experimental tetanus the administration of antitoxin is ineffective once a lethal dose has been fixed and symptoms of central nervous system tetanus are present. But since in human beings there is no way of telling whether a lethal dose has been fixed, the clinician should continue to use antitoxin in local or central tetanus in hopes that a lethal dose has not yet been fixed by the body tissues.

In discussing the cross-circulation experiments we must repeat that our

various control procedures have shown the cross-circulation itself to be harmless. Even marked differences in blood pressures and blood volumes are not sufficient to cause death. The cross-circulation experiments summarized in Table IX reveal that death of the donor due to medullary necrosis does not cause the death of the recipient. But death does occur in a significant percentage of the recipients cross-circulated with donors dying of tetanus, whether the toxin is injected intravenously or into the lumbar cord. We feel, therefore, that these experiments lend weight to our hypothesis that the tetanus donors absorbed into their blood streams some lethal agent sufficient in amount, in some instances, to kill the recipients. It is obvious, of course, that tetanus toxin *per se* could not have killed the recipients because in every case before the anastomosis was opened the recipient received much more than enough antitoxin to neutralize the toxin injected into the donor. No recipient ever exhibited any signs of tetanus.

One may well ask why every recipient did not die, especially since we injected into the donor's cord comparatively large amounts of tetanus toxin. We have mentioned before that in a long continued cross-circulation experiment the blood streams of both animals will eventually have equal concentrations of the formed and chemical elements in the blood provided that one animal is not receiving into its blood stream a steady supply of some element. But where, as in these experiments, one animal (the donor) is constantly absorbing into his blood stream some element (the lethal agent), the concentration of this element in his blood stream will be persistently higher than the concentration in the blood of the recipient. It is likely that the donor dies as soon as a fatal amount of this lethal agent is present. For these reasons one could hardly expect that in every instance the recipient also would receive a fatal amount before the donor dies.

In the second paragraph above, we have made a statement that requires further qualification. We should have said that death occurs in a significant percentage of the recipients *when* the cross-circulation is carried out under nembutal or when nembutal is given after the cross-circulation has been stopped, and even, in a small percentage, when no respiratory depressant is used. This brings up the question whether the lethal agent acts chiefly on the respiratory center. If this were true it might explain why the additional burden of nembutal was sufficient to kill so many of our recipients.

Our observations on the manner of death* of the animals in Experiment I suggested that possibly the respiratory center is that vital center on which the new lethal agent acts. It is also a common clinical observation that sudden respiratory failure is often the terminal event in patients dying of tetanus. If death is due to a poisoning of the respiratory center, it follows that toxin injected into or close to such centers should act more quickly and that to cause death a smaller dose should be required than in the case of injection into the lumbar cord. This we found to be true. When toxin is injected into the

* So constant was this manner of death that by watching the respirations we could almost always tell when death was near.

medulla oblongata death occurs twice as quickly, and a smaller dose suffices to cause death. After symptoms are present the injection of a usually safe dose of nembutal will kill the animal in a short time. We have also shown that when toxin is given intravenously the administration of enough nembutal or avertin to stop convulsions shortens life.

For these reasons, then, we think it likely that the respiratory center may be that vital center upon which the lethal agent acts.

Although the utmost care must be taken in applying to human beings the results of experiments on dogs, our observations on the manner of death and on the effect of respiratory depressants suggest that such drugs should be used with extreme caution in cases of human tetanus. This raises the question of using artificial respiration and respiratory stimulants in cases of human tetanus. It is interesting that, in the Johns Hopkins Hospital, there have been several cases of tetanus in which respiration has suddenly ceased and been restarted by artificial respiration. In one case respirations stopped and were started again eight times.

Further investigations on the problems mentioned in this paper are being carried on.

CONCLUSIONS

Experimental evidence has been presented to support the following statements:

(I) A small fraction of one lethal dose of tetanus toxin placed in a non-vital area of the central nervous system causes death.

(II) A similar dose of toxin in other organs of the body does not cause death.

(III) The principal factor causing death is not the metabolic changes consequent to the constant muscular spasms.

(IV) The lethal agent does not travel up the spinal cord.

(V) Death cannot be attributed to a multiplication of the tetanus toxin molecule.

These facts have led us to suggest that tetanus toxin in the spinal cord is altered into or liberates a different lethal agent which is transported to and has its lethal effect on vital centers.

Further evidence is presented which supports this suggestion and which makes it appear likely that:

(VI) The lethal agent is not neutralized by tetanus antitoxin.

(VII) The lethal agent may act chiefly on the respiratory center.

(VIII) The lethal action of this new substance may be enhanced by respiratory depressants.

BIBLIOGRAPHY

- ¹ Meyer and Ransom Arch f exper Path u Pharmacol, 49, 380, 1903
- ² Meyer and Frohlich *ibid*, 79, 55, 1916
- ³ Firor and Jonas Bull Johns Hopkins Hosp, 62, 91, 1938
- ⁴ Zupnik Wien klin Wchnschr, 15, 89-92, 1902

- ⁵ Filoi and Lamont ANNALS OF SURGERY, 108, 941, 1938
- ⁶ van den Hoven van Genderen Centralbl f Bakt u Parasit, 128, 129-138, 1933
- ⁷ Abel, Hampil, Jonas, and Chalian Bull Johns Hopkins Hosp, 62, 522-563, 1938
- ⁸ Abel, Evans, and Hampil *ibid*, 59, 313-324, 1936
- ⁹ Gesell, Bricker, and Magee Am Jour Physiol, 117, 423, 1936
- ¹⁰ Marshall, Walzl, and LeMessurier Jour Pharm and Exper Ther, 60, 472-486, 1937
- ¹¹ Abel, Hampil, and Jonas Bull Johns Hopkins Hosp, 56, 317-336, 1935
- ¹² Abel and Chalian *ibid*, 62, 610, 1938
- ¹³ Firor Am Jour Physiol, 96, 146-152, 1931
- ¹⁴ Shumacker, Lamont, and Metcalf Arch Surg, 39, 959-972, 1939
- ¹⁵ Courmont and Doyon Le Tetanos Paris, 1899
- ¹⁶ Zupnik Deutsche med Wchnschr, 26, 841, 1900
- ¹⁷ Zuger and Friedmann Proc Soc Exp Biol and Med 38, 283, 1938

THYROID DISEASE IN A NONENDEMIC AREA

A THIRD SERIES OF OBSERVATIONS

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IN 1937, I reported observations on a second series of patients with thyroid disease treated at the Charity Hospital in New Orleans, increasing the total number of cases reported to 662 for the period from January, 1927, to July, 1936^{1, 2} I am now bringing this report up to date by adding 393 cases treated in the same hospital from July, 1936, to June, 1939, making a total of 1,055 cases for a period of nearly 12½ years During this interval, there were approximately 590,000 admissions to the hospital, about half of which were surgical I mention these last figures to emphasize again that thyroid disease is infrequent in this area

Table I shows that the general mortality for the second and third series was the same and was only half as high as that reported in the first series Further analysis of these figures in later tables reveals that in the third series there was an increase in the mortality rate in toxic patients as compared with that reported in the second series The general mortality remained about the same because of an increase in the number as well as a decrease in the mortality of nontoxic goiters

TABLE I

INCIDENCE AND MORTALITY OF THYROID DISEASE IN CHARITY HOSPITAL
IN NEW ORLEANS

From January 1, 1927, to June 1, 1939

First series	341 cases	26 deaths	7.6%
Second series	321 cases	12 deaths	3.7%
Third series	393 cases	15 deaths	3.8%
Combined series	1,055 cases	53 deaths	5.0%

In Table II the cases are grouped as diffuse nontoxic, diffuse toxic, nodular nontoxic, and nodular toxic, following, as heretofore, the classification of the American Society for the Study of Goiter, a classification which I have found increasingly satisfactory from a clinical standpoint It was noted in going over the records of the third series that there was more general adoption of this nomenclature by members of the various staffs In view of the difficulty sometimes encountered in making a positive diagnosis in certain mildly toxic goiters even with the patient at hand, the difficulty of attempting to confirm or disprove the diagnosis simply from the charts is

Submitted for publication, June 19, 1939

obvious. Consequently, unless there was definite collective evidence which pointed to a different diagnosis, the opinion of the historian with regard to toxicity or nontoxicity was accepted. Using this criterion, I found it necessary in a few cases, less than 10 per cent, to take the liberty of reclassifying the patients. In all instances this was a matter of transferring them from the toxic to the nontoxic group. In classifying the cases as nodular or diffuse, the original diagnosis, physical examination, operative notes and gross pathologic description were all taken into consideration, it being remembered that this classification is a purely clinical one.

TABLE II
DISTRIBUTION OF THYROID DISEASE IN CHARITY HOSPITAL IN
NEW ORLEANS

<i>Diffuse Nontoxic</i>			
First series	87 cases	6 deaths	8.0 %
Second series	101 cases	1 death	0.99 %
Third series	62 cases	0 deaths	0 %
Combined series	250 cases	7 deaths	2.8 %
<i>Diffuse Toxic</i>			
First series	94 cases	13 deaths	13.8 %
Second series	61 cases	4 deaths	6.5 %
Third series	84 cases	7 deaths	8.3 %
Combined series	239 cases	24 deaths	10.0 %
<i>Nodular Nontoxic</i>			
First series	77 cases	1 death	1.3 %
Second series	99 cases	3 deaths	3.0 %
Third series	191 cases	3 deaths	1.5 %
Combined series	367 cases	7 deaths	1.9 %
<i>Nodular Toxic</i>			
First series	83 cases	6 deaths	7.2 %
Second series	60 cases	4 deaths	6.7 %
Third series	56 cases	5 deaths	9.0 %
Combined series	199 cases	15 deaths	7.5 %
<i>Total Nontoxic Cases</i>			
First series	164 cases	7 deaths	4.2 %
Second series	200 cases	4 deaths	2.0 %
Third series	253 cases	3 deaths	1.2 %
Combined series	617 cases	14 deaths	2.3 %
<i>Total Toxic Cases</i>			
First series	177 cases	19 deaths	10.8 %
Second series	121 cases	8 deaths	6.6 %
Third series	140 cases	12 deaths	8.6 %
Combined series	438 cases	39 deaths	8.9 %

Examination of Table II reveals that for the combined series in nontoxic goiters there were approximately 1.5 times as many nodular as diffuse goiters, whereas in toxic goiters there were 1.2 times as many diffuse as nodular ones.

The mortality for the combined series of 617 nontoxic goiters was 2.3 per cent (Table II). In the third series, there was a definite decrease in the mortality of nontoxic cases, a decrease in the diffuse type from 8 per

NONENDEMIC THYROID DISEASE

cent in the first series to zero per cent in the third, while the mortality in the nontoxic variety remained about 15 per cent throughout the three series

In the toxic cases, the mortality for the combined series was 89 per cent (Table II). In the diffuse group, the mortality in the second series (65 per cent) was half that for the first series (138 per cent), but in the third series the mortality was higher than that in the second group (83 per cent). In the nodular toxic group, the mortality in the first and second series was approximately the same, about 7 per cent, but in the third series there was an increase to 9 per cent.

To summarize, there has been a consistent improvement in the results obtained in the nontoxic patients subjected to operation. In the toxic group, the results in the second series were better than those in the first or third, but the mortality in all three series is still entirely too high.

TABLE III

RACIAL INCIDENCE AND MORTALITY OF THYROID DISEASE

<i>First Series</i>			
White	193 cases	11 deaths	5.7%
Negro	148 cases	15 deaths	10.1%
<i>Second Series</i>			
White	152 cases	3 deaths	2.0%
Negro	169 cases	9 deaths	5.3%
<i>Third Series</i>			
White	146 cases	4 deaths	2.7%
Negro	247 cases	11 deaths	4.4%
<i>Combined Series</i>			
White	491 cases	18 deaths	3.7%
Negro	564 cases	35 deaths	6.2%

An analysis of the racial incidence of thyroid disease (Table III) shows that in the first series white cases were 1.3 times more frequent than Negro cases, but in the third series the figures were reversed, there being 1.7 times as many Negro as white cases. The mortality in thyroid disease as a whole has been consistently higher in the Negro—in the first and third series, about 1.7 times as high, in the second, 2.6 times as high.

TABLE IV

RACIAL INCIDENCE AND MORTALITY OF TOXIC THYROID DISEASE

<i>First Series</i>			
White	104 cases	10 deaths	9.6%
Negro	73 cases	9 deaths	12.3%
<i>Second Series</i>			
White	71 cases	2 deaths	2.8%
Negro	50 cases	6 deaths	12.0%
<i>Third Series</i>			
White	58 cases	3 deaths	5.2%
Negro	82 cases	9 deaths	11.0%
<i>Combined Series</i>			
White	233 cases	15 deaths	6.4%
Negro	205 cases	24 deaths	11.7%

With reference to toxicity in the two races, analysis shows that 47.5 per cent of the total white cases and 36 per cent of the total Negro cases were toxic. The mortality in Negroes with toxic goiter has been higher than that in whites in each series, and about twice as high in the combined series, 6.4 per cent, as compared with 11.7 per cent (Table IV). This ratio in mortality was approximately the same when the toxic goiters of the third series were grouped as nodular and diffuse, as shown in Table V.

TABLE V

RACIAL AND SEX INCIDENCE OF DIFFUSE AND NODULAR TOXIC GOITER
THIRD SERIES

	Diffuse Type		Nodular Type	
	Operative Cases	Deaths	Operative Cases	Deaths
White male	10	1	2	1
White female	27	1	19	0
Total white cases	37	2 (5.4%)	21	1 (4.8%)
Colored male	5	1	4	1
Colored female	42	4	31	3
Total colored cases	47	5 (10.6%)	35	4 (11.4%)

In the third series, the mortality in white male patients with toxic goiter was 16.6 per cent and in colored males 22.2 per cent, as compared with 2.2 per cent in white females and 9.6 per cent in colored females (Table V).

I have expressed the opinion in former papers of this series that toxic thyroid disease when it occurs in the Negro in this community tends to be more severe and more grave than the same disease in white individuals, and offered as a possible explanation the tendency of the Negro to postpone medical consultation, particularly when pain is not an outstanding feature of his disease. Such delay is especially detrimental in toxic goiter in which, as we all now recognize, the best measure for lowering mortality is to treat the disease before the heart, liver and other organs have suffered severe damage.

Mortality is, as a rule, higher in toxic nodular goiter than in toxic diffuse goiter, but in our first series the mortality was distinctly higher in the diffuse group and in the last two series it was approximately the same. Why this difference exists I cannot say, but after analyzing the deaths, it seems likely that we have been better able to treat the complications resulting from prolonged toxicity, such as cardiac complications, pneumonia, liver damage and so on, but less able to prevent and treat crises, the more common cause of death in patients subject to this catastrophe.

I stated in my last report and repeat here that it has been very difficult to give our toxic patients adequate quiet and rest during the preoperative preparation. This situation has existed for a long time, but has been particularly acute during the past three years. In the fall of 1936, part of the hospital was demolished to clear a site for the erection of a new building and as a consequence there has been much noise and confusion and in-

creased crowding in the already overcrowded wards, both medical and surgical. Frequently it has been difficult to arrange for a patient with toxic thyroid disease to have a bed to himself, particularly in the Negro wards where "doubling-up" is so often necessary. During 1936-1937, when, perhaps, the confusion and crowding were at their height, 40 toxic cases were treated by operation, with a mortality of 15 per cent. During 1937-1938 and 1938-1939, there were 55 and 45 toxic cases respectively, with a mortality of about 6 per cent each year (Table VI). In retrospect, it is surprising that we fared as well as we did, although the high mortality rate is not attributable to this one factor alone. Four of the deaths among the toxic group and, certainly, the three deaths in nontoxic patients cannot be blamed upon the crowding and confusion incident to the building program.

TABLE VI

RACIAL AND SEX INCIDENCE AND MORTALITY OF TOXIC THYROID DISEASE
THIRD SERIES

	Toxic Goiter					Nontoxic Goiter					Toxic and Non-toxic
	Male		Female		Totals	Male		Female		Totals	
	White	Negro	White	Negro		White	Negro	White	Negro		
1936-1937 Operations	6	3	10	21	40	5	6	30	57	98	138
(July-July) Deaths	1	2	1	2	6	0	0	0	0	0	6
1937-1938 Operations	5	1	20	29	55	2	6	31	52	91	146
Deaths	1	0	0	2	3	0	0	0	0	0	3
1938-1939 Operations	1	5	16	23	45	5	3	15	41	64	109
Deaths	0	0	0	3	3	1	1	0	1	3	6
Total operations	12	9	46	73	140	12	15	76	150	253	393
Total deaths	2	2	1	7	12	1	1	0	1	3	15

In the patients of the third series, thyroidectomy was performed either because the goiter was toxic or was causing pressure symptoms, or, as in a few instances, because the patient wanted it removed for cosmetic reasons. There were still a very few instances in which, so far as I could tell from the records, the thyroid was removed simply because the patient had an enlarged gland and was in the hospital. It is interesting that many patients date their symptoms to a time when someone told them that they had a goiter or an enlarged neck. This frequency with which the development of symptoms is concomitant with the knowledge of a goiter's being present makes it difficult to diagnose thyroid disease of mild toxicity or to evaluate the rôle of the thyroid in causing pressure symptoms.

All toxic patients, whether the goiter was nodular or diffuse, were given iodine in some form as a preoperative measure and, as a rule, the period of administration was sufficiently long. Forty-six patients with nontoxic goiter, most cases of which were diagnosed as such by the staff operating on the patient, also received iodine as a preoperative measure. This, perhaps, is a manifestation of our lack of confidence in our differentiation of nontoxic from toxic goiter.

The fact that it has been impossible to insure adequate quiet and rest for many toxic patients has already been mentioned. The diet, except in a

few instances, was high in calories and carbohydrates. The importance of a diet adequate in proteins, especially in patients with great weight loss, has recently been emphasized. Attention is now being called to the use of vitamins, especially vitamin B-complex in the preparation of toxic patients. One important point generally neglected in this third series of cases was frequent recordings of the weight of toxic patients during preoperative preparation. In the absence of such records, it was difficult to estimate whether the diets were adequate or not, but I believe it likely that the high caloric diets offered were frequently insufficient for the very toxic patients.

There were some instances in which attempts to prepare the patients for operation were not persisted in over a sufficient length of time to induce a satisfactory remission.

The most commonly used sedative was luminal, bromide being next in frequency. Toxic patients with cardiac decompensation and those with auricular fibrillation were digitalized before operation. Quinidine was used preoperatively in one case. In two patients roentgenotherapy was employed as a preoperative measure, in one, the dosage seems to have been adequate, although there was too long an interval between roentgenotherapy and operation, in the second, the dosage was inadequate, only two exposures being administered.

In summary, it appears that there was an attempt to prepare adequately most of the toxic patients studied. Proper rest and quiet were particularly difficult to obtain, as already mentioned. The sufficiency of the diet is questionable, but the absence of weight recordings allows no definite conclusions with reference to this point. Whether toxicity was properly evaluated and whether the optimum time and the correct procedure were chosen is difficult to judge from a study of the records, particularly records which, although improved over those used in the two previous series, are not yet perfect. However, a study of the severe reactions following operation in some of the nonfatal cases and of the causes of death in the fatal ones leads me to believe that some patients were either not properly evaluated or were subjected to more surgery than they could bear.

In the three-year period covered by this last study, there were 415 operations performed on 393 patients. The fact that these operations were done by 48 different operators emphasizes again, as in the former series, that it is difficult for any one surgeon on this hospital staff to gain extensive experience in thyroid surgery and management. It follows, too, that it is impossible for interns, nurses, and anesthetists to become properly acquainted with the potentialities of thyroid disease and the seriousness of toxic goiter, yet it is well known that in the proper surgery of thyroid disease team work is an essential factor.

Of the 415 operations, 363 were performed under ethylene anesthesia and 36 under ether, the remainder under cyclopropane, local, or nitrous oxide. In only three cases was it recorded that avertin was used as a basal anesthetic.

Among the 140 toxic patients, 22 had two-stage operations, one of these patients died. Eighteen had only the first stage of an anticipated two-stage procedure, four of these patients died and 14 did not return for completion of the operation. One hundred had subtotal removal of the gland, seven of these died.

There were 253 nontoxic patients, of these 41 had lobectomies, 16 had simple enucleation of an adenomatous growth, and 196, of whom three died had subtotal removal.

There was evidence in the records that 12 nonfatal cases suffered injury to the recurrent laryngeal nerves at operation, eight of these were nontoxic and four toxic. In half the cases the injury was bilateral.

Crile³ has aptly said that it is easier to prevent than to treat the complications of hyperthyroidism. It is generally agreed that in the prevention of crisis, it may be wise to transfuse the patient immediately after operation, that an oxygen tent is invaluable, that morphine should be administered in adequate doses, that ice packs and other measures to decrease elevated temperatures should be used, and that an adequate intake of fluids and carbohydrates should be insured.

In reviewing the cases in this series, I found that transfusions were very rarely given. Oxygen tents are not always available in this institution and our patients cannot afford to rent them. Oxygen itself is always available, but often must be given by means of a nasal catheter. Crile points out that in the use of the oxygen tent the refrigeration obtained may be as important as the oxygen itself. In this series, morphine was ordered freely, but it is difficult to insure its being given frequently enough simply by leaving a *prn* order. Practically all toxic patients received intravenous saline and glucose postoperatively, but many received it in inadequate quantities. The majority received iodine postoperatively. I prefer to give iodine for at least a few days postoperatively, hoping to carry on the iodine routine so that no exacerbation of symptoms will occur because of its withdrawal.

A most important part of the postoperative regimen is watching carefully for signs of hemorrhage or tracheal obstruction. There was evidence that we have at times been lax in this respect, as three patients died from respiratory obstruction, these could perhaps have been saved by performance of tracheotomy at the proper time.

TABLE VII

CAUSES OF DEATH FOLLOWING OPERATION FOR TOXIC THYROID DISEASE

Laryngeal obstruction	2
Crisis	8
Operation during increase in toxic symptoms	4
Presence of pneumonia at the time of operation	1
Cause of crisis not determined	3
Cardiac failure	1
Embolism	1

Analysis of the Deaths in the Third Series—*Operative Deaths* The 12 fatalities in the 140 toxic patients operated upon were analyzed in an attempt to determine the main causes of death. These causes are summarized in Table VII and include laryngeal obstruction, crisis, cardiac failure and embolism. It is possible that eight of these deaths were preventable.

There were three deaths in the group of 253 operations for nontoxic goiter. Two patients died from postoperative pneumonia and one from laryngeal obstruction.

Nonoperative Deaths—In the third series, 23 nonsurgical patients with toxic goiter died. The race and sex of the patients as well as the type of gland present are indicated in the following summary:

Nodular toxic goiter	1 colored male
	3 colored females
	2 white males
	2 white females
Diffuse toxic goiter	3 colored males
	8 colored females
	1 white male
	3 white females

Here, as in the group of operative cases, we found about two Negro deaths to one white. The main causes of death in these cases were as follows:

Cardiac failure	4 deaths
Pneumonia	2 deaths
Crisis	17 deaths

The following factors were considered precipitating causes of the crisis in eight of the fatal cases:

Extraction of teeth	2 patients
Respiratory infections	3 patients
Furunculosis	1 patient
Suppurative parotitis	1 patient
Fracture of femur	1 patient

Eight of these deaths occurred between November and March and 15 between April and October. Rives and Seais,⁴ of our staff, recently studied 21 instances of thyroid crisis occurring in nonsurgical patients, of which 16 crises developed during the months of June to October, inclusive. During these months, the temperature in New Orleans is consistently above 70° F, frequently above 90° F. The humidity here is consistently high throughout the year, only slightly lower in summer than in winter. These observers believe that the high temperature and humidity tend to embarrass the heat-regulating mechanism in toxic goiter, and that the increased frequency of thyroid crisis in summer is significant of that fact.

That our problem in thyroid disease is not peculiar to this institution is demonstrated in reports by Thompson and his co-workers⁵ from Cook County Hospital of Chicago, an institution which is in many ways comparable to

ours They reported that, in the years between 1931 and 1933, the mortality in exophthalmic goiter for the whole hospital was 13.1 per cent, in toxic adenoma 9.8 per cent, in nontoxic adenoma 4.1 per cent, and in simple goiter 2.6 per cent. These figures are comparable to ours. The second report of these authors covered the period from 1932 to 1937 and in it they compared the mortality of their own cases with that obtained in the remainder of the hospital, over which they exerted no control. In the control series, there were 572 toxic goiters with a mortality of 9.4 per cent, in their own series, there were 317 toxic goiters with a mortality of 2.8 per cent. In the nontoxic goiters, their mortality was half that in the control series. On the author's own services, they reduced the mortality rate in toxic goiters to one-sixth what it was previously. They summarize the regimen under which they succeeded in reducing the mortality rate as follows. Each patient was treated as an individual problem, surgery was withheld until the condition of the patient justified operation, a special high caloric diet for toxic patients was developed and operation was rarely performed unless the patient had gained weight, surgery was performed by a selected group of surgeons. These authors maintain that the policy of letting many surgeons get limited experience in operating upon patients with toxic goiter, together with the policy of keeping hospital beds free for use by quick turnover of these patients, will inevitably maintain a high mortality rate. With this I am in complete accord.

We note with some degree of consolation that Lehman and Shearburn⁶ report a series of cases which embraces an experience similar to ours in Negro patients. Their figures show a 0.84 per cent mortality for white and 9.4 per cent for Negro patients with toxic goiter. This leads us again to our former conclusion that a disease is most a problem where it is least a problem. Our efforts must be directed to more adequate care, particularly in Negro patients.

SUMMARY

(1) Observations on 393 surgical cases of thyroid disease treated in the Charity Hospital in New Orleans between July, 1936, and June, 1939, are added to those of two previous reports, bringing the total number of cases to 1,055 for the period from January, 1927, to June, 1939. Of this total number, 491 are white and 564 are Negro patients.

(2) The mortality for patients with toxic thyroid disease in the third series, 8.6 per cent, is higher than that of the second but lower than that of the first series. However, in proportion there are twice as many toxic Negro patients in the third as in either of the other two series.

(3) Hyperthyroidism is a more grave and more severe condition in the Negro than the same disease in white individuals. The mortality is consistently higher in all series for Negro patients—1.3, 4.3, and 2.1 times higher in the first, second, and third series, respectively.

(4) The mortality rate for patients with nontoxic thyroid disease has

decreased from 42 per cent in the first series to 23 per cent in the third series

(5) The preoperative preparation, the operative procedure and the postoperative care given patients in this series are analyzed and some of the factors contributing to the high mortality rate are pointed out

(6) Fifteen deaths among the 393 surgical patients of the third series are analyzed, as well as 23 nonsurgical deaths that occurred in the same period of time

REFERENCES

- ¹ Maes, U, Boyce, F F, and McFetridge, E M Clinical Problems of Thyroid Disease in a Nonendemic Area *Am Jour Surg*, (n s) **24**, 232-253, May, 1934
- ² Maes, U, Boyce, F F, and McFetridge, E M Further Observations on Thyroid Disease in a Nonendemic Area, Analysis of 662 Surgical Cases and 16 Nonsurgical Deaths *ANNALS OF SURGERY*, **105**, 700-716, May, 1937
- ³ Crile, G, Jr Management of the Patient with Hyperthyroidism Preoperative and Postoperative Care *Surg Clin N Amer*, **16**, 1051-1059, August, 1936
- ⁴ Rives, J D, and Sears, W H Personal Communication
- ⁵ Thompson, W O, Taylor, S G, Meyer, K A, and McNealy, R W Experiences in Treating Toxic Goiter in a Large Public Hospital *Ann Int Med*, **12**, 217-231, August, 1938
- ⁶ Lehman, E P, and Shearburn, E W Thyrotoxicosis, Including a Study of the Duration of Preoperative Treatment *ANNALS OF SURGERY*, **109**, 712-728, May, 1939

AUTOGENOUS TRANSPLANTATION OF A FIBROSARCOMA OF SKIN DURING THE APPLICATION OF A FULL-THICKNESS SKIN GRAFT

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FEW INSTANCES of auto-inoculation of human malignant tumors have been recorded in the literature in recent years. Instances of deliberate or unintentional transplantation of tumors to distant sites in the course of surgical procedures are extremely rare, and those reported involved chiefly carcinomata. The direct "seeding" of the operative wound or a serous membrane, and the dislodging of emboli to form distant metastases, in the course of operation for biopsy or removal of a tumor, have been recognized for many years. The dangers involved have been the subject of much bitter debate^{1, 2, 3}. Accidental transmission to other individuals of viable malignant cell nests contained in aspirated fluids or incompletely killed vaccines have been reported^{4, 5}. The most fascinating transplants are those in which the invasive cells appear to have been carried by the patient's hand, or to have been inoculated in a new site by the direct contact of an ulcerated malignancy with an uninvolved surface^{6, 7, 8, 9}. Shattock and Dudgeon,⁹ in 1915, reviewed the cases in the literature up to that time. Instances of transmission to other individuals, as by coitus, have been reported. Implantation of malignant cells in the wall of a viscus distal to the primary site, after having been carried by the contents of the organ or surgical instrument such as a bougie, has been recorded. The development of a second cancer *de novo*, or metastasis by the more common routes to a site of previously lowered resistance, must also be considered. Adequate microscopic study is often lacking in the older reports.

Two instances of successful, intentional human auto-inoculation of malignancies have been cited by Butlin⁶. (1) Portions of a disseminated carcinoma in the skin were transplanted by Hahn, in 1887, probably as a skin graft to uninvolved areas of skin, (2) a sarcoma of the breast was transplanted by Cornil, in 1891, to the opposite breast. The latter is the only instance of autotransplantation of sarcoma which we have discovered. The only previous instance of accidental transplantation in the course of skin grafting, which we have discovered, is that in which cells were transferred from the site of operative removal of a mammary carcinoma to a single

donor area on the thigh during the application of pinch grafts to the skin defect¹⁰ Three cases of recurrence in skin grafts applied over incompletely excised tumors, one of which was a sarcoma, have been recorded^{11, 12, 13} The present case is, we believe, the second recorded instance of transmission of a sarcoma to a new site on the same individual as a result of an operation, and the first case in which a malignancy was transferred during the application of a full-thickness pedicle skin graft

Case Report—T W S, white, male, age 43, married, railroad brakeman, was seen in August, 1937, complaining of an ulcer on the heel for several weeks The family history was negative for malignancy The past history revealed no serious illnesses Twenty-three years previously a freight car had run over the right heel, resulting in an avulsion of a portion of the os calcis The wound healed slowly, but eventually became covered by skin The patient continued to work, wearing a pad in the heel of the shoe At intervals, usually during the summertime, the site of the old injury would break down but slowly heal again under local treatment, without the patient losing time at work In the spring of 1937, he fell down some stairs, injuring the right heel, with subsequent development of an ulcer which gradually increased in size, discharged serous material, and failed to heal after local treatment

The temperature, pulse and respirations were normal, the blood pressure 106/70 The patient was well developed, well nourished, and in no pain The general physical examination was noncontributory except for palpable cervical and inguinal nodes and small varicose veins, more marked on the left leg About one-third of the right heel was missing In the skin overlying the site of the old injury was a 4 cm round, firm, pink, ulcerated area, raised 0.5 cm above the surface, fixed to the underlying tissues, and exuding a small amount of serous discharge The Wassermann and other laboratory tests were negative

A tentative diagnosis of osteomyelitis was made On September 3, 1937, the granulating area was excised, and the exposed bone curetted, no infected areas were found Microscopic preparations of the removed tissue showed little change in the stratified squamous epithelium Fibrous strands, irregularly arranged, were separated by myxomatous tissue and were not sharply differentiated from the underlying stroma The cells varied slightly in size, shape and staining quality, and contained small nucleoli Some edema, with small numbers of polymorphonuclear leukocytes and lymphocytes, was present near the surface A diagnosis of subacute inflammation of fibroelastic tissue was made elsewhere A comparison of the tissue with that removed subsequently reveals that the process was invasive at this time On September 23 and 30, 1937, the entire granulating area on the heel was covered with pinch grafts taken from the left thigh The wounds healed completely and the patient was discharged from the hospital, October 6, 1937

Two weeks later, thinning was noted in the grafted area, with two small ulcers at the outer margin By November 11, 1937, two months after the first excision, the grafts had entirely disappeared and were replaced by clean granulation tissue On November 12, 1937, the granulating area over the heel was again excised A flap of skin the size of the exposed area of heel was dissected upward from the anterior surface of the left thigh with a very liberal pedicle attachment The right heel was brought over to the left thigh, and the skin flap was sutured to the skin margins of the heel with silkworm-gut Gauze and cotton packs were placed under the attached skin flap, as well as over the sutured skin edges, so that the margins of the granulating wound on the right heel could not come in contact with the skin of the left leg or the pedicle at the point of attachment to the left thigh After padding, a plaster encasement was applied for eight days to hold the foot in position An unusually abundant blood supply developed through the pedicle in that interval and the graft remained quite pink after

being severed. The V-shaped incision in the left leg was closed with a pressure dressing. No pathologic examination was made of tissue removed at this time. Both wounds healed satisfactorily, the graft on the heel retracted slightly at the skin edges over the upper aspect, but the blood supply remained ample. The patient was discharged, November 27, 1937.

During the next two months, the granulation tissue surrounding the graft on the heel definitely changed in character, becoming angry in appearance with greater vascularity and marked proliferation. It spread centrifugally from the margins to cover an area twice the former size, the extension could be noted from day to day. The graft was elevated above the surface by the proliferative growth and gradually shrank to half its original size. Local compresses with aluminum acetate and 1,200 R units of roentgenotherapy were ineffective in reducing the granulations. Cultures for fungi were negative, a course of iodides gave no improvement. Severe pain developed in

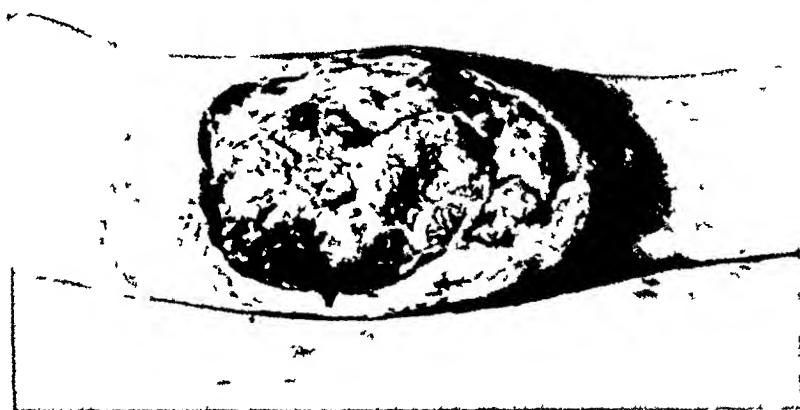


FIG 1—Right heel showing fungating mass and discolored skin. Note the shrunken skin graft to the right of the midline.

the heel and leg, requiring sedation. The patient was readmitted, January 26, 1938. In the five months since he was first seen he had lost a moderate amount of weight. The right heel was covered by a 12x9 cm red, soft, friable, heaped-up, fungating mass which tended to overhang the border of nonulcerated skin and bled freely at the slightest touch. The skin for a distance of 3.5 cm beyond the edge of the lesion was edematous and dusky purple in color. The well-preserved skin graft measured 4.5 cm in diameter (Fig 1). No nodes were palpable in the inguinal region. A diagnosis of fibrosarcoma was made from a biopsy of the heel.

On January 29, 1938, the right leg was amputated 10 cm below the knee. Dense, white, firm tissue, distal to the graft and overlying the os calcis, appeared to be continuous with the bone, no other bone was involved. No necrosis was seen beneath the surface. The graft measured 0.8 cm in thickness. Microscopically, the tissue was qualitatively similar to that previously seen—very vascular, made up of cells growing in strands and whorls undermining the squamous epithelium, and sharply demarcated from the underlying connective tissue (Fig 2). The cells were very large, hyperchromatic, anaplastic, with large nucleoli and many mitoses. Definite areas of spindle and myxomatous cells with smaller nuclei were present. The tissue was found between spicules of bone, but did not invade tendon. At the junction of the old graft with the tumor many large vessels, most of which were thrombosed, were found, but no tumor emboli were demonstrated. Focal areas of slight lymphocytic infiltration were found deep in the tissue with polymorphonuclear exudate and gram-positive *Cocci* on the

surface only. The amputation wound healed promptly and the patient was discharged, February 12, 1938.

Shortly after discharge, the point on the left thigh at which the pedicle to the skin graft had been excised showed signs of infection, although no open wound had been

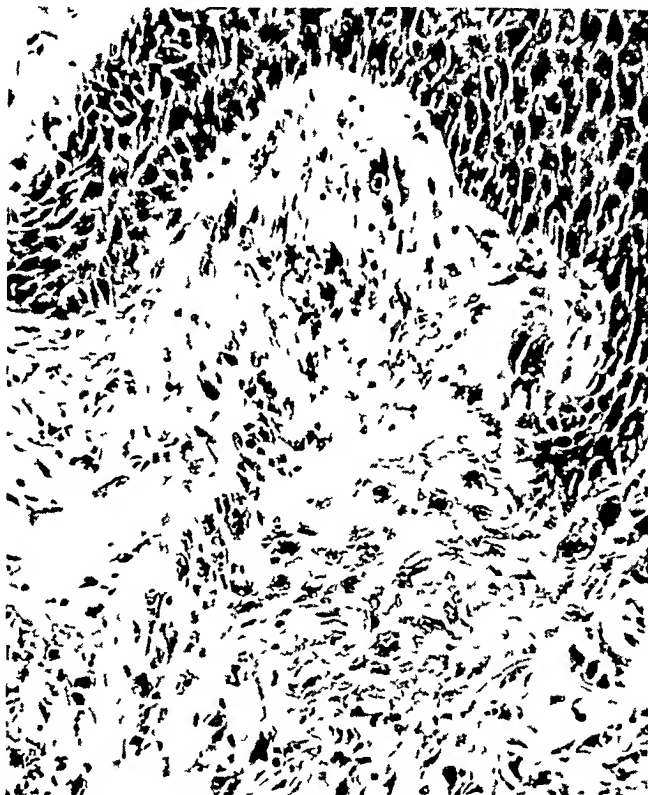


FIG 2 —Photomicrograph of tissue from the right heel (X110)



FIG 3 —Left thigh showing the scar at the site of removal of the full thickness graft, with the ulcer at the point of attachment of the pedicle. The scars of the previous pinch grafts are also visible.

present for three months. Warm saline compresses were employed with little benefit. A circumscribed ulcer 3 cm in diameter developed, similar in appearance to the previous one on the right heel, with friable heaped-up edges, rising 4 Mm above the surface and partly covered by epithelium. The base was pale, not granular, and was raised

above the surface of the surrounding skin (Fig 3) On two occasions aerobic hemolytic *Staphylococcus aureus* and anaerobic beta hemolytic *Streptococcus* were cultured from this ulcer, mixed cultures of these organisms caused no lesion when injected into the skin of a rabbit On March 12, 1938, an area of skin 7x4.5 cm containing the ulcer together with the deep fascia overlying the muscle was excised The floor of the ulcer was composed of white tissue, 4 Mm in thickness, well demarcated from the underlying fat Microscopically, the tissue was identical with that from the right heel, except for more anaplasia and increased numbers of mitoses—four to six per high power field (Fig 4) Gram-positive Cocci, chiefly in phagocytes, were present only on the surface At the growing edge, perivascular lymphocytic infiltration was present with

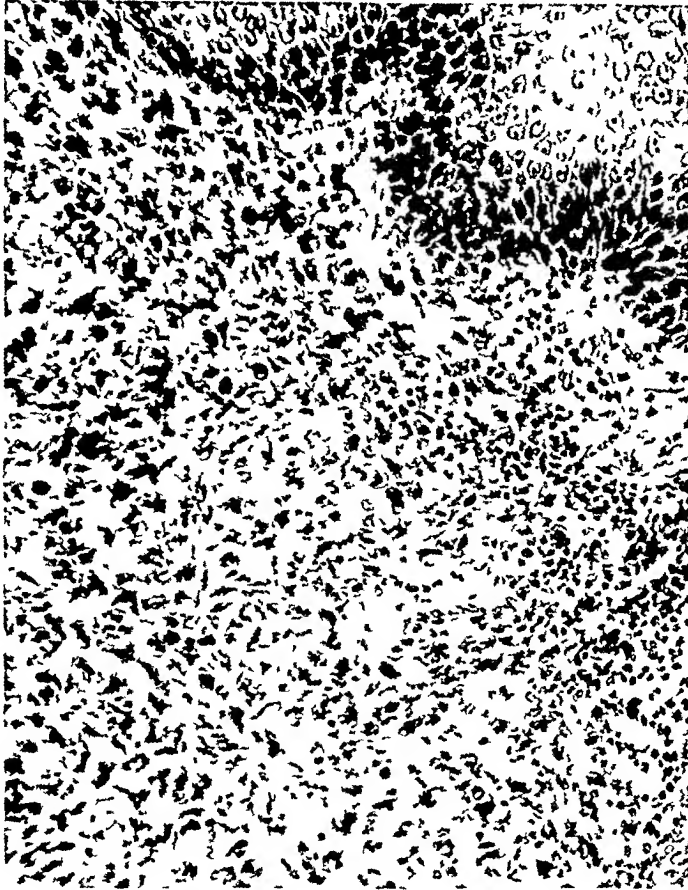


FIG 4—Photomicrograph of tissue from the ulcer on the left thigh (X110)

a large amount of phagocytosed brown pigment, which gave a strong staining reaction for iron The patient was discharged, March 20, 1938, with the wound well healed, no inguinal nodes were present He received 1,800 R units of roentgenotherapy post-operatively over the left thigh and inguinal region Up to this time, December 20, 1938, there has been no sign of recurrence at either site, and the patient is up and about, using an artificial limb satisfactorily

Comment—The tumor in the present case apparently originated in granulation tissue by malignant change as the result of repeated traumata with secondary local infections over a period of 23 years Bloodgood¹⁴ has pointed out the difficulty in determining the malignancy of such tumors, particularly at the first examination

It is possible that, by some unnoticed break in technic, tumor cells were carried, perhaps by the knife, from the malignancy on the heel to the upper end of the incision on the opposite thigh at the time the graft was raised

and applied. Contamination by direct contact during the time the two wounds were opposed seems less likely, for they were carefully isolated by dressings. In either event the transplant appeared at the site which was left intact for the preservation of blood supply to the graft. It would seem unlikely that cells were transferred later when the pedicle was excised, for the knife was used only on the "clean" area of the thigh and no sutures were taken.

Although sarcomata are known to spread chiefly through the blood stream, such an explanation is unlikely in the absence of other metastases. Since fibrosarcoma is highly invasive locally, but metastasizes slowly, direct extension is a possibility. Bloodgood,¹⁴ however, points out that excision need not be carried far beyond the invading border to effect complete removal. This would suggest that such a possibility was a remote one in the present case, but two attempts at local excision were unsuccessful. The short time the graft was in contact with both areas would have necessitated a very rapid rate of growth for the tumor to pass by direct extension through either the lymphatics or blood vessels of the graft. However, rapid growth was noted clinically.

Handley¹⁵ has advanced the theory and shown that carcinoma of the breast spreads chiefly by permeation of lymphatics. He has also traced the spread of a melanosarcoma of the skin of the leg for a distance of 17 cm., and believes the mode of initial spread in this tumor is identical with that of carcinoma. Davis and Traut¹⁶ have described the growth of new blood vessels from the recipient area into grafts, and find them frequently growing up with great rapidity through thrombi in the transplanted vessels of the graft. By an analogous method, this sarcoma could have extended back through the pedicle graft to the donor area. Thrombosed vessels in the graft were demonstrated at the time of amputation, but no tumor cells were shown in them, although serial sections were not cut. It is possible that any tumor cells present were destroyed by increase in fibrous tissue, this has been noted in the experimental production of tumor emboli. It is impossible to tell which of the suggested routes of transfer is the correct one.

SUMMARY

An instance is reported of accidental autogenous transplantation of a fibrosarcoma of skin which developed in the scar of an old injury, following repeated traumata and infections. The transfer from the right heel to the left thigh was effected during the application of a full-thickness pedicle skin graft either by direct extension through the graft, or by accidental contamination of the incision at the donor site.

REFERENCES

- ¹ Bainbridge, W. S. Biopsy and Cancer, A Review. *Med Rec*, 91, 705, 1917.
- ² Greenough, R. B. The Handling of Early and Doubtful Cases of Cancer. *ANNALS OF SURGERY*, 66, 385, 1917.

- ³ Wood, F C Diagnostic Incision of Tumors J A M A , 73, 764, 1919
- ⁴ Ewing, James Neoplastic Diseases A Treatise on Tumors 3rd Ed, W B Saunders Co, Philadelphia, 145, 1928
- ⁵ Lecene, P, and Lacassagne, A Accidental Inoculation of Malignant Tumor in Man Ann d'Anat Path , 3, 97, 1926
- ⁶ Butlin, H T Address on Surgery on the Contagion of Cancer in Human Beings Automoculation Brit Med Jour , 2, 255, 1907
- ⁷ Dyke, S C Suggested Automoculation of a Rodent Ulcer Brit Med Jour , 1, 932, 1921
- ⁸ Lack, H L A Contribution to the Operative Treatment of Malignant Disease of the Larynx, with Special Reference to Danger of Cancerous Wound Infection Lancet, 1, 1638, 1896
- ⁹ Shattock, S G, and Dudgeon, L S Wound Inoculation in Carcinoma with Experiments Upon the Action of Local Cytocides as a Means of Dealing with It Proc Roy Soc Med , 1, 8 (Path Sect), 1914-1915
- ¹⁰ Spies, J W, Adair, F E, and Jobe, M C An Accidental Autogenous Transplantation of a Mammary Carcinoma to the Thigh During a Skin Graft Operation A Case Report Amer Jour Cancer, 20, 606, 1934
- ¹¹ Dunham, E K Epithelioma Following Skin Grafting Med Rec , 48, 170, 1895
- ¹² Knox, L C The Relationship of Massage to Metastasis in Malignant Tumors ANNALS OF SURGERY, 75, 129, 1922
- ¹³ Lyle, H H M Recurrent Fibrosarcoma of Skin ANNALS OF SURGERY, 72, 634, 1920
- ¹⁴ Bloodgood, J C The Surgical Treatment of Cutaneous Malignant Growths J A M A , 55, 1615, 1910
- ¹⁵ Handley, W S Cancer of the Breast and Its Treatment 2nd Ed, Paul B Hoeber, New York, 381, 1922
- ¹⁶ Davis, J S, and Traut, H F Origin and Development of the Blood Supply of Whole-Thickness Skin Grafts An Experimental Study ANNALS OF SURGERY, 82, 871, 1925

BLOOD-BORNE PYOGENIC INFECTIONS OF BONES AND JOINTS*

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JOHN HUNTER, when asked by a pupil whether he had not, the year before, stated an opinion on some point directly at variance with one he had just put forth, is said to have replied "Very likely I did, I hope I grow wiser every year." At another time, when asked whether he had written so-and-so, he replied "Never ask me what I have said, or what I have written, but if you will ask me what my present opinions are, I will tell you"¹ These remarks are those of a sincere student of nature and are as applicable in the present day as they were some hundred years ago, for with the ever advancing knowledge of the medical sciences, we learn more of the underlying facts concerning the diseases of the human body as time goes on. In no other condition are these assertions more applicable than they are to that of acute hematogenous osteomyelitis, the conception of which has undergone constant changes during our lifetime.

Thirty years ago, the surgeon's endeavor in treating this disease was to eliminate, at once, the local focus from within the bone by means of some type of radical procedure. There were those who advocated the chiseling away of a surface of the cortex of the diaphysis and the removal of all the medullary contents by means of a curet, while others resected the entire diaphysis from within its periosteal covering. These were drastic, time-consuming operations which produced severe shock to patients already weakened by sepsis. If death was not hastened, a long convalescence was bound to follow, which terminated, only too often, in a crippled and deformed limb or an amputation. Gradually, we came to realize that the infection could not be eradicated at once, *en masse*, through these methods, and that the mutilating operative procedures added inestimable damage to an already embarrassed circulation of the bone, causing more bone necrosis than the disease itself.

The operative treatment of the bone lesion was much simplified by Starr,² in 1922, when he showed the actual manner in which the infection spread outward from the metastatic focus within the metaphysis. Because of his findings, Starr advised early, simple drainage of the focus, incision of the overlying soft parts until pus was found or, in cases in which the exudate had not as yet reached the subperiosteal space, the drilling of a few holes through the cortex of the metaphysis. This proved to be a decided advance in the treatment of the bone lesion as, by means of simple incision down to the abscess adequate drainage is accomplished and tension is relieved.

¹ Read before the Joint Meeting of the New York Surgical Society and the Philadelphia Academy of Surgery February 8, 1939. Submitted for publication February 1, 1939.

without breaking down the local resistance of the tissues, or materially damaging the already embarrassed circulation to the bone. A further improvement in the treatment of the bone lesion was made by Orr,³ in 1929, when he recommended adequate drainage of the lesion, packing the wound in the soft parts with vaselined gauze, and instituting complete rest of the part, through immobilizing the limb within a plaster encasement, and infrequent dressings. His recommendations, however, were slowly accepted, as the procedure was considered by many to be *unsurgical*. The results obtained by those who have employed Orr's method, however, more than establish its efficiency, and we believe that it is one of the greatest advances, so far made, in the treatment of acute inflammatory lesions of bone, for, through complete rest of the diseased part, not only from motion but also from the irritation of needless dressings, the local resistance of the tissues is enhanced, further spread of the infection is prevented, contamination by secondary organisms is precluded, pain is averted, and a state of complete muscular relaxation is obtained.

It is significant that none of the early writers on the subject of acute hematogenous osteomyelitis have laid sufficient stress upon the presence of an active blood stream infection. Starr dismissed the subject in these few words: "The blood stream infection is most frequently transient and cultures may be obtained but rarely. When the blood culture is positive and repeated, a general septicemia results, and recovery is uncommon." Orr says: "A patient with an acute bone infection and a septicemia already established (one might better say a severe septicemia since many of them, if not all, really have a septicemia from the beginning) calls for the exercise of great surgical judgment both at operation and subsequently. At the operation drainage is the essential thing, the operation must not stop short of it no matter where it leads one."

Finally, in 1934, Fraser,⁴ of Edinburgh, drew our particular attention to the specific underlying condition of the acute osteomyelitis, that is, the blood stream infection. "A haemic infection of a bone," he said, "presupposes that staphylococcal organisms are already circulating in the blood stream and *that then localization in the bone is but a local manifestation of the general disturbance*. To the surgeon the local infection has been the important item in the clinical picture. It is upon this that he has concentrated his ingenuity and his skill, but is it right that we should regard the local focus as a most deplorable and regrettable manifestation? There is such a thing as a fixation abscess,—nature's method of producing a defensive area from which the factors of immunity are organized and developed."

This conception of the disease which we call hematogenous osteomyelitis places the bone lesion in a position of being merely an incidence in the course of a blood stream infection, which may be transitory or may continue until death claims the patient. We believe it is generally conceded that the blood stream infection, in many cases of this condition, is transitory and, therefore, the patient when first seen is often merely suffering from a localized abscess

involving the cancellous tissue of a bone and its surrounding soft parts or, in other words, an acute osteomyelitis. In these cases the treatment need only be directed toward the evacuation of the pus and to the promotion of the healing of the lesion, for the patient seldom dies of this single focus. New procedures for the improvement in the treatment must, therefore, be directed toward the so-called fulminating type of case, for in this type the patient is suffering primarily from the effects of the blood stream infection, a septicemia, accompanied by a local focus within a bone, which early in the disease is usually in its first stages of development. It is in this group of cases that the high mortality occurs, from septicemia, or from pyemia later in the course of the disease. In our experience, fatalities are almost always due to a septicemia or pyemia and never to the bone lesion (Table I). Pyrah and Pain⁷ reached a similar conclusion through their studies of the post-mortem findings in 51 fatal cases. All these deaths could be ascribed directly to causes other than the bone focus, the result of a septicemia or a supervening pyemia with abscesses involving vital organs.

TABLE I
ANALYSIS OF 38 DEATHS IN A SERIES OF 218 CASES
OF HEMATOGENOUS OSTEOMYELITIS

Causes of Death			
Septicemia			
Staphylococcus	11	}	19
Streptococcus	3		
Unknown	5		
Pyemia			
Staphylococcus	8	}	10
Streptococcus	1		
Unknown	1		
Pericarditis (Staphylococcus)			5
Endocarditis (Streptococcus)			1
Meningitis (Streptococcus)			1
Chronic sepsis			2
			<hr/>
		Total	38

Evidently the mortality from this disease is not due to the osteomyelitis but to the preceding blood stream infection, which may cause death through a septicemia or pyemia. Thus, such endeavors that are made to save life should be directed primarily against the underlying blood stream infection, rather than concentrating them entirely upon one of the metastatic lesions which happens to be within a bone or joint.

Further, there is some question as to the advisability of too early drainage of the bone lesion. The advocates of early operation appear to be of the opinion that the disease arises within the bone and that all the systemic symptoms result from this focus, therefore, the earlier drainage is instituted the better it is for the individual. Those who view the bone lesion as an inci-

dence of the general blood stream infection believe, as Fraser does, that "There is such a thing as a fixation abscess,—nature's method of producing a defensive area from which the factors of immunity are organized and developed," and further that "The prognosis is improved if we have the courage to delay operation until the focus is reasonably well established and, having chosen the most opportune time, to restrict the operation to one involving the minimum of interference and yet securing drainage and relief of tension" Robertson,⁶ a collaborator of Stair and until recently a strong advocate of early drainage, now states "Recently, the writer has felt that an early operation gives no help to the patient The problem in an early case

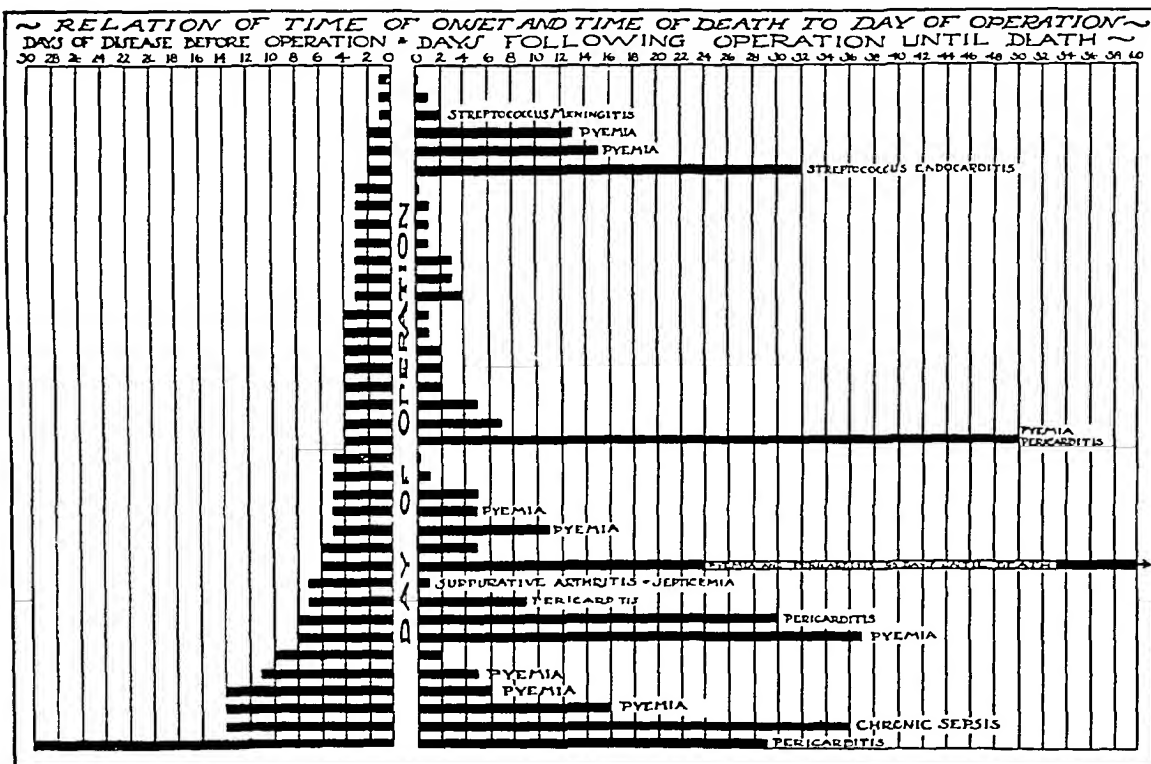


CHART I—Showing the relation of the time of onset and the time of death to the day of operation

is one of combating a blood stream infection, dealing with the toxins and organisms that are present, and until some approach to an equilibrium has been reached surgery, in so far as incision of a local lesion goes, has nothing to offer When the condition has reached a point where pus is present, then a simple drainage may be of advantage"⁶

We agree in general with the opinions expressed by both Fraser and Robertson, as five years ago, having reviewed our case histories, we discovered that 16 of the 38 deaths occurred before the third postoperative day and nine others before a week had elapsed (Chart I) Thus 60 per cent of all the deaths in this series of 218 cases occurred during the first seven days following operation Thirty of these children had been sick for less than seven days before operation and all were markedly septic Three died as early as 24 hours following operation It is useless to surmise as to how many lives might have been saved if the drainage of the focus had been

postponed until a time when the bodily resistance had increased sufficiently to combat the active blood stream infection. Some of these patients would have surely died from septicemia or pyemia, regardless of what procedure was followed, as the infection in many instances was overwhelming in its intensity, but in others we believe that more favorable results might have been obtained if operative intervention had been delayed, at least until the resistance of the body had been strengthened through the establishment of a physiologic fluid balance, as none of these patients received intravenous clyses before operation.

FIVE CASES ILLUSTRATING FULMINATING TYPES OF THE DISEASE, IN WHICH EARLY OPERATION WAS INEFFECTUAL

Case 1—*Staphylococcus Osteomyelitis of the Right Tibia, Pyemia* F T, female, age nine, was admitted to the hospital, February 13, 1921. Five days previously, she had fallen down, subsequent to which she had walked a few steps but thereafter remained in bed, as she seemed to be getting steadily worse. On admission she was very toxic. Temperature 104.2° F, W B C 28,000, polymorphonuclear leukocytes 87 per cent. There was marked swelling and tenderness over the right tibia, especially its lower end, and marked edema around the ankle.

The child was immediately operated upon. The periosteum was found entirely raised from the bone throughout its entire length by seropurulent fluid. The medullary cavity contained a small quantity of exudate of the same character. The anterior surface of the bone was cut away and the medullary cavity cleaned with a curet. Dakin tubes were inserted. Culture from the pus, as well as the blood culture, showed *Staphylococcus aureus*. A hypodermoclysis of 500 cc was administered on the following day and another, of 450 cc, on February 15. At this time there was marked rigidity of the neck, the arms were held flexed and attempts to extend them caused pain. Hyperesthesia of the entire body was present. There was marked swelling with acute tenderness in the region of both parotid glands. On February 16, there was much more swelling of the parotid glands, the child died that afternoon, three days following operation and eight days after onset of the disease. Shortly after death a spinal tap showed clear fluid.

Autopsy—Multiple abscesses in the heart muscle with patchy hyaline degeneration, injection of pia arachnoid of the brain, multiple abscesses of the lungs, acute parenchymatous degeneration of the spleen, acute parenchymatous degeneration and multiple miliary abscesses of the kidneys, acute parenchymatous degeneration and solitary miliary abscess of the liver.

COMMENT—The pyemia in this case must have been present at the time of operation, three days before the death of the child, who had been sick for only five days at that time. Operation upon the bone focus could hardly be expected to be of help in this case.

Case 2—*Osteomyelitis of the Femur* E D, male, age three, had been sick but two days, when admitted to the hospital, December 1, 1922. His condition was extremely toxic. Temperature was 105.2° F, W B C 20,000, polymorphonuclear leukocytes 85 per cent. The region just below his left knee, which was held flexed, was swollen, hot and tender. The child was immediately operated upon, a three-inch incision being made along the lateral surface of the thigh, just above the condyle. The periosteum was found to be separated from the lower end of the femur and the space between it and the bone was filled with thin pus. The child died 12 hours later. There was no record of blood culture or culture of the pus. There were no roentgenograms taken.

COMMENT—This was apparently a case of acute, fulminating osteomyelitis of the lower end of the left femur, with marked sepsis. The infection spread rapidly from the metaphysis to the subperiosteal space on the lateral surface of the femur. Death, which occurred 12 hours after operation, was due to septicemia, though pyemia may have occurred.

Case 3—*Staphylococcus Osteomyelitis of the Humerus*. Suppurative Pericarditis. F. P., female, age nine, was admitted to the hospital, May 3, 1924. She had been ill for one week with pain in her left shoulder, which gradually became worse and the soft parts about the shoulder became swollen. There was high temperature and later pain in the left elbow. On admission, temperature 102° F, WBC 19,800, polymorphonuclear leukocytes 80 per cent. The soft parts about the left shoulder were found to be tense and indurated and any motion at the joint produced pain. Signs of inflammation extended down the arm to the elbow joint. The capsule of the elbow joint was distended and fluctuant. The right arm was also swollen and painful. The child's condition was serious. She was delirious, dyspneic, and there was a pericardial friction rub which could be heard over the entire precordium.

The child was immediately operated upon. The periosteum was found stripped from the whole length of the left humerus. The bone was white and apparently dead. Pus, which was found infiltrating through all the tissues, was evacuated. Pus was also found under the periosteum of the right humerus. A *Staphylococcus haemolyticus* was recovered from the pus and from the blood cultures. The septic temperature continued and, May 17, the pericardial sac was aspirated and 140 cc of thin, greenish pus was obtained. At the same time 200 cc of straw-colored fluid was aspirated from the left pleural cavity. The culture from the pus showed *Staphylococcus haemolyticus*. Two days later, May 19, the pericardium was drained. The patient died, however, on June 3, 1924.

COMMENT—In this case, we have an infection which localized in the proximal metaphysis of the left humerus and shaft of the right humerus, as well as in the pericardium. There was a definite bacteriemia during the entire time the child was in the hospital. Death was apparently due to the pericarditis, rather than to any localization of the infection in the bone.

Case 4—*Staphylococcus Osteomyelitis of the Femur*. Suppurative Pericarditis. G. M., female, age 11, was admitted to the hospital, December 7, 1931. She had been ill for one week, the condition having started with a high temperature and pain in the region of the left hip joint. On admission, the child was delirious. Temperature 102.4° F, WBC 15,800, polymorphonuclear leukocytes 86 per cent. The left hip was swollen and tender and the superficial veins over it were markedly dilated. There was little motion in the joint and any attempt to move it produced severe pain.

The child was immediately operated upon. The left hip joint was drained through an incision along the posterior border of the trochanter. A large amount of pus was evacuated. Cultures from the wound and the blood showed *Staphylococcus aureus*. On December 11, four days after admission, there were 500 colonies of bacteria per cubic centimeter of blood. The condition of the child grew steadily worse, though two transfusions were given, and, December 14, there were definite signs of an acute pericarditis. The patient died, December 16, 1931, nine days after admission.

COMMENT—This patient was admitted in a state of sepsis and with a well-localized lesion of the left hip joint. There was no indication as to the portal of entry of the infection. *Staphylococcus aureus* was obtained from both the pus in the hip joint and the blood stream. The lesion apparently

started in the upper metaphysis of the neck of the femur and rapidly penetrated the bone into the joint. The child developed an acute suppurative pericarditis, which caused her death.

Case 5—*Staphylococcus Aureus Haemolyticus* Pyemia, Acute Osteomyelitis of the Right Femur. Suppurative Arthritis of the Right Knee. N. C., female, age four and a half, was admitted to the hospital, February 5, 1933. One week previously, she had fallen on her right knee. Two days later, she complained of pain around the joint and her temperature rose to 105.2° F. On admission, the child was found to be extremely toxic. Temperature 104° F, WBC 31,000, polymorphonuclear leukocytes 92 per cent. The region about the right knee was swollen and tender and motion caused extreme pain. There were signs of fluid in the joint. The knee joint was aspirated and 5 cc of blood stained fluid was obtained, from which a hemolysing *Staphylococcus aureus* was obtained. The knee joint was drained and the limb was placed on a posterior molded splint. Culture from the blood showed many colonies of *Staphylococcus aureus*. The child's condition grew worse, though she was transfused on two different occasions. She died, February 10, 1933, five days after admission.

Autopsy—Bilateral bronchopneumonia, serofibrinous pleurisy, fibropurulent pericarditis, fibropurulent peritonitis, focal abscess in the myocardia, acute vegetative endocarditis, focal suppurative necrosis of the liver, multiple abscesses of the ileum, cecum and ascending colon, with perforation of the ileum, multiple abscesses of the kidney. *Staphylococcus aureus haemolyticus* was obtained by culture from all of these lesions.

COMMENT—There seems to be little doubt that, in this case, the osteomyelitis of the lower end of the femur was merely one of many metastatic lesions, which followed a *Staphylococcus aureus* blood stream infection. The autopsy showed the many lesions caused by this overwhelming blood infection. Death cannot be ascribed to the osteomyelitis and an earlier operation could hardly have been expected to save her life, as the pyemia developed so rapidly, for she was operated upon on the fifth day of the disease and died five days later.

The deaths were also studied in relation to the elapsed time of the disease before operation. In 128 instances, in which the children had been sick for less than a week, 30 died, a mortality of 23 per cent, while in the remaining 90 cases, in which the disease had lasted longer than a week, only eight died, a mortality of 8.9 per cent. The findings at operation in the former group were, in many instances, those of an early infection. The foci in 13 of these were entirely confined to a metaphysis, in five of which, only a few drops of thin, blood-stained exudate were obtained on drilling the cortex, and, in six others, though an exudate was found beneath the periosteum, it was serosanguineous in character. It is believed that the inflammatory focus within the bone, in many of these cases, had advanced so little that a definite abscess wall had as yet not been established and that, through postponement of the operation, at least until the water balance of the body had been increased, the local resistance of the tissues might have been increased. For the sake of argument in favor of this procedure, we present the modern practice of delaying incision of pyogenic infections of soft tissues until an

abscess has fully formed. Why, then, it may be asked, should a pyogenic infection of the medullary tissue of a bone be incised before it has consolidated as an abscess?

THREE CASES, ILLUSTRATING THE FINDINGS AT OPERATION, IN WHICH THE INFECTION HAD NOT AS YET BECOME LOCALIZED

Case 1—*Streptococcus Osteomyelitis of the Right Humerus*. Septicemia. C. L., male, age eight, was admitted to the Pediatric Service, March 2, 1927. For five days, he had had pain in the right arm, which was accompanied by drowsiness and loss of appetite. His mother had noticed some swelling of the right arm for the first time on the day of admission, at which time his temperature was 106° F, pulse 124. The child was transferred to the Children's Surgical Service on the following day. At that time his condition was extremely toxic and he had severe, generalized convulsions. W. B. C. 15,000, polymorphonuclear leukocytes 90 per cent.

The patient was immediately operated upon, an incision being made over the anterolateral aspect of the upper end of the right humerus. The muscles were split and retracted. The periosteum was found to be edematous and raised. About one dram of thin, serosanguineous exudate was found beneath it. The cortex was drilled and about half a dram of material of the same character was obtained from the medulla. A small window was raised in the cortex. A second incision was made over the lateral aspect of the lower portion of the humerus. Here, the periosteum was found to be normal, but was incised and a hole was drilled and serosanguineous exudate obtained. The patient died within five hours after operation. Culture from the wound showed the *Streptococcus haemolyticus*.

COMMENT—A case of acute, blood stream infection with an osteomyelitis of the right humerus, due to the *Streptococcus haemolyticus*. A thin, serosanguineous exudate was found at operation. The patient died five hours after operation. If the operation had been delayed until the body fluid had been replaced, would the outcome have been different?

Case 2—*Streptococcus Osteomyelitis of the Left Femur*, Septicemia. M. C., male, age 11, was admitted, July 31, 1927, three days after he had returned from a two weeks' vacation in the country, apparently in perfect health. Twenty-four hours later, he complained of headache and went to bed. He soon began to have pain in the left inguinal region and left knee. His appetite was fairly good and there was no elevation of temperature. Bowels did not move. That night he was restless and apparently in pain. A slight epistaxis occurred during the night. The day before admission, he had a slight fever in the morning, which increased in the afternoon and he became delirious. He continued to have pain in the left groin, left knee and down to the left foot. He vomited once, the day before admission. On admission, the child appeared critically ill, with rapid respirations and delirium. Temperature was 106.4° F. The axillary nodes were enlarged, especially those on the left side. He complained of pain on movement of the left leg, referring it to the hip. Internal and external rotation of the left thigh caused no pain, but flexion and extension did.

An immediate operation was performed, a lateral incision being made through the skin and muscle just below the great trochanter down to the bone. A small quantity of clear, serous fluid was evacuated. The periosteum was loose, although not raised. Three drill holes were made through the cortex of the bone and were connected by chiseling. Sterile gauze packing was used and a dry, sterile dressing was applied. Culture from the wound showed *Streptococcus haemolyticus*. The child died on the following day, four days after the onset of the disease.

COMMENT—This case is one of an early *Streptococcus haemolyticus* infection, with localization in the femur, which had not progressed to abscess formation

Case 3—Staphylococcus Osteomyelitis of the Right Tibia Septicemia J K, male, age nine, was admitted to the hospital, December 21, 1927, four days after a fall, in which he injured his right knee Twenty-four hours later he complained of severe pain in the upper part of the right leg and soon after he had a chill and vomited His parents said he had fever He continued to vomit and refused to eat At the time of admission his condition was markedly toxic Temperature was 106° F, pulse 140 There was swelling in the region of the right knee which extended up into the lower part of the thigh and down to the middle of the leg The local temperature was increased and there was some redness of the overlying skin of the part Motion at the knee joint was limited and painful and the entire area was tender There was no maximum point of tenderness W B C 9,000, polymorphonuclear leukocytes 88 per cent

He was immediately operated upon, an incision being made along the lateral aspect of the thigh, just above the external condyle of the femur The periosteum was split and separated for a distance of about one inch and the bone was drilled No pus was found A second incision was then made over the anteromesial aspect of the tibia Here the periosteum was found to be edematous and it separated easily The metaphysis of the bone was drilled at this point, releasing a small amount of brownish-yellow pus under slight pressure A small window was raised from the cortex and the wound was packed with gauze One hour following the operation, the patient had a mild convulsion and died within four hours Blood cultures taken at the time of operation showed no growth after 24 hours Culture from the lesion showed the presence of *Staphylococcus aureus*

COMMENT—This case is of interest, as one of a severe septicemia with acute osteomyelitis of the metaphysis of the tibia The child had been sick for only three days, and the lesion of the bone had not advanced to the state of abscess formation The blood count indicated that there was little bodily resistance to the infection The question arises whether the outcome might not have been different if the fluid balance of the body had been adjusted before operation had been undertaken

Robertson,⁶ who stated that "no case should be operated upon in which there is not a definite abscess," bases his conclusion on the supposition that the presence of the toxins from the local focus may stimulate the human organism to the production of antitoxin, and that "while a high degree of natural antitoxin may not be a factor in the direct destruction of the organism, yet it is not unreasonable to suppose that the neutralization of the toxin will allow other defense agents to have an unimpaired action in the destruction of the organisms"

Fraser⁴ states "I feel infinitely less anxious about the future of the osteomyelitis case when there is a pronounced local bone focus with early suppuration than I am when the local reaction is indefinite and suppuration is absent or delayed" From our own experience, we believe that nothing is to be gained through incision of an inflamed tissue in which the infection is still diffuse, but that when localization has occurred, the abscess should be drained

It may be said by the advocates of early incision, that postponement of operation will increase the amount of bone necrosis, through intermedullary

tension and undue stripping of the periosteum by the exudates. This occurs in neglected cases. However, it is believed that during the time that the inflammatory process is consolidating, these factors are not active and that gross circulatory interference to the bone occurs only after the abscess has formed and commences to point.

It should become evident to anyone who studies a large number of cases that the course of acute hematogenous osteomyelitis differs materially in respect to the type of causative organism as it is found that the manifestations of the disease, when due to the *Staphylococcus aureus*, are quite different to those when due to the hemolytic *Streptococcus*. Though either type of organism may produce a septicemia or pyemia, accompanied by a local focus within a bone, the reaction of the body is quite different to each of these organisms, in fact, being caused by different organisms, each of these conditions is a separate, specific disease. Heretofore, little attention has been paid to the actual causative factor and, in consequence, in the past, the treatment of all cases of hematogenous osteomyelitis, whether due to the *Staphylococcus* or the *Streptococcus*, has been the same.

Robertson states that "There is little similarity between the two conditions, and unless we make a clean cut distinction between *Staphylococcus* and *Streptococcus* osteomyelitis, there cannot be any clear understanding of the serologic problems that enter into the treatment of the condition. It is useless, from the standpoint of treatment, to group all cases of osteomyelitis and to consider the mortality of the whole group." The difference in the two diseases, he says, is due entirely to the nature of the toxin of the *Staphylococcus* and its ability to produce necrosis, and that the *Staphylococcus* may have recurring attacks, while the *Streptococcus* never does.

In the early part of 1933, soon after reviewing our previous cases of acute osteomyelitis, we began to make modifications in the manner of handling these cases. Since then, through the gradual introduction of improved methods, a more conservative form of procedure has been established in caring for these patients, as we began to treat the individual patient, rather than using a routine procedure in all cases.

These changes may be briefly outlined as follows. On admission of the patient to the hospital, a tentative diagnosis being made, the individual's general physical condition is built up through the administration of intravenous clyses of a solution of normal saline, with 5 per cent glucose, and blood transfusions, when indicated. In order to ascertain the type of organism responsible for the condition, a blood culture is taken at this time and samples of exudates from joint effusions or superficial abscesses, if present, are obtained for bacterial investigation. The involved limb in the meantime is completely immobilized in splints or by a plaster encasement. When the fluid equilibrium of the body is established, which should be accomplished within six to 18 hours, the question of draining the lesion may be considered. In the presence of a well-formed abscess in the soft parts or a pyarthrosis with

thick pus, operation is not further delayed. If, however, a thin exudate has been obtained through aspiration, or the causative organism has been shown to be the *Streptococcus haemolyticus*, operation is postponed, though a distended joint is always emptied of its effusion by aspiration before the limb is immobilized. An active focus can be cured in some instances through immobilization of the part and, in others, the inflammation becomes localized and makes the establishment of drainage at a later date easier and more efficient. Sulfanilamide should be given in those cases in which the *Streptococcus haemolyticus* is shown to be the causative agent. (There were three cases in our series in which it was used.)

A CASE ILLUSTRATING THE USE OF IMMOBILIZATION OF THE LIMB AND DELAY OF OPERATION UNTIL THE INFECTION BECAME LOCALIZED

Case Report—*Streptococcus Osteomyelitis of the Femur Pyarthrosis of the Hip* R. A., male, age ten, was admitted, June 1, 1937, with a five day history of pain and swelling around the right hip joint. He had had drainage from the right ear for several months. The boy was acutely ill, with a temperature of 105° F. He was dehydrated. There was swelling and marked limitation of motion of the right hip joint. The hip joint was aspirated and thin pus was obtained. *Streptococcus haemolyticus* was cultured from the pus. A blood culture at this time was positive for *Streptococcus haemolyticus*. The fluid balance of the patient was restored and several small blood transfusions were given. The right hip was immobilized by means of a plaster spica. For three and one-half weeks the boy remained acutely ill, with a septic type of temperature. Sulfanilamide was given during this period. Then his general condition improved and the temperature subsided. Several changes of the plaster spica were made during the following five months. Whenever the spica was left off for a few days, however, there would be a rise in temperature, during this period.

Five months following admission, fluctuation developed over the upper third of the right thigh, accompanied by a rise in temperature. This area was incised and drained, a few sequestra were removed, and a plaster spica reapplied. The boy remained in the hospital for another six months and was discharged with the wound healed. Roentgenograms at this time showed marked destruction of the femoral head and neck. There was some loss of function of the right hip. At the present time, the wound is healed. There is still some loss of motion of the hip joint, though ankylosis is not present.

COMMENT—Though limitation of motion is still present, the destruction of the head and neck was not great, as compared with other cases of the *Old Series* treated by traction, where secondary infection so often ensued.

The operative procedure which is employed is as simple as is consistent with the establishment of adequate drainage which must be obtained, wherever it leads one. The most direct route of approach to the lesion is chosen by ascertaining the maximum point of tenderness before the anesthetic is administered. The incision through the soft tissues must be ample enough to expose the underlying bone. If pus is found beneath the periosteum, the membrane is widely incised without stripping it further from the bone. If no pus is found, the periosteum is incised over its most edematous part and the edges are carefully pushed apart with an elevator, exposing a small area of the cortex of the metaphysis. The cortex is then drilled in several places with a quarter-inch bit, or a small "trapdoor" is raised with a gauge. The

cancellous bone of the metaphysis should not be disturbed. The edges of the wound in the soft tissues are then gently packed apart with vaselined gauze and the wound is dressed with a copious dressing of dry gauze, after which a plaster encasement is applied to the limb. This should extend well beyond the joints contiguous to the involved bone, so as to obtain complete immobilization of the part as any slight motion within it, by causing pain, will hinder the relaxation of the tense muscles about the lesion. Suppurative joints are drained in a similar manner, the capsule being widely incised in one or more places. (A pyarthrosis of the knee joint, for example, is drained through two parallel incisions, one on either side of the patella.) The edges of the wound in the overlying soft tissues are then packed apart with vaselined gauze, care being taken not to place any within the joint cavity. The wound is then dressed and the limb is immobilized in a plaster encasement. Though most cases of *Staphylococcus pyarthrosis* are due to the direct extension from a focus in a neighboring metaphysis, experience has shown us that the drainage of the joint is adequate in relieving the metaphyseal lesion, as has been reported.⁷ The encasement must not be removed until odors from the dressings become offensive, nor should a window be cut in it for inspection or dressing of the wound. Orr³ states that "Following operation, with a sick patient, the desire to be doing something often leads to excesses of treatment that are undesirable. Even if all the symptoms persist following such an operation, nothing is to be gained by further disturbance of the wound. Dressings, which are nearly always resorted to, should, therefore, not be done." To this we thoroughly agree.

Following operation, the general physical condition of the patient must be improved, through careful nursing and attention to the physiologic needs of the body. During the early days, the water balance and nutrition must be stabilized through venous clyses of normal saline and glucose and a simple, nutritious diet. Blood transfusions are most important for increasing bodily resistance.

Since employing this procedure, in the treatment of acute hematogenous osteomyelitis or pyarthrosis, we have cared for 50 children with one or the other of these conditions, though complete immobilization was not used in the earlier cases. We are, therefore, able to compare the results obtained in these cases with those of our former series, in which more radical methods of treatment had been used routinely, without preoperative preparation of the patient. Though the number of cases in the *New Series* is small, compared with those of the *Old*, the improvement shown in the results is so striking that we believe we may report our findings to advantage.

The causative organisms are known in 185 of the 218 cases of the *Old Series*, and in all of the 50 cases of the *New Series* (Table II).

The mortality of the *Old Series* was 16.7 per cent, and that of the *New* 10 per cent.

In cases with positive blood cultures, the mortality of the *Old Series* was 46 per cent, and that of the *New* 29 per cent.

The mortality of cases of infection due to the *Staphylococcus* of the *Old Series* was 16.5 per cent and of *Streptococcus haemolyticus*, 17 per cent, while in the *New Series* it was *Staphylococcus*, 10.3 per cent, and *Streptococcus haemolyticus*, 9.5 per cent.

In cases with positive blood cultures, the mortality of those cases due to *Staphylococcus* of the *Old Series* was 46.5 per cent and of *Streptococcus haemolyticus*, 44.5 per cent, while in the *New Series* it was *Staphylococcus*, 27 per cent, and *Streptococcus haemolyticus*, 33.3 per cent.

TABLE II

TWO SERIES OF CASES OF OSTEOMYELITIS, IN WHICH THE MORTALITY OF THE MORE CONSERVATIVE METHOD IS COMPARED WITH THAT OF OLDER METHODS

Type of Organism	Old Series						New Series					
	Culture from Focus			Positive Blood Culture			Culture from Focus			Positive Blood Culture		
	No of Cases	Deaths	Per Cent	No of Cases	Deaths	Per Cent	No of Cases	Deaths	Per Cent	No of Cases	Deaths	Per Cent
<i>Staphylococcus</i>	151	25	16.5	41	19	46.5	29	3	10.3	11	3	27.0
<i>Streptococcus</i>	34	6	17.0	9	4	44.5	21	2	9.5	6	2	33.3
Totals	185	31	16.7	50	23	46	50	5	10	17	5	29

There were five deaths among the 50 cases of the *New Series*. Three of them occurred in cases of infection due to the *Staphylococcus* and two due to the *Streptococcus*.

Eleven patients with *Staphylococcus* osteomyelitis, two of whom had complicating pyarthrosis, were treated by immediate immobilization in a plaster encasement following operation (Table III). One of them died two months later from a *Staphylococcus* meningitis, following an acute middle ear infection and mastoiditis. Eight other patients with *Staphylococcus* osteomyelitis, two of whom had a complicating pyarthrosis, were treated with plaster encase-

TABLE III

LOCAL TREATMENT OF STAPHYLOCOCCUS CASES

Procedures	No of Cases	No of Deaths	Cause of Deaths
Orr technic	11	1	Two months after operation, <i>Staphylococcus</i> meningitis following mastoiditis
Encasement immobilization 2 wks after operation	8	0	
Immobilization in splints after operation	8	2	(a) Five months later—pyemia (b) Four days later—pyemia
Carrel-Dakin treatment	2	0	
Totals	29	3	

ments which were applied within two weeks following the operation. None of these died. Eight patients with *Staphylococcus* osteomyelitis, one with a pyarthrosis, had the involved limb immobilized by means of molded plaster splints immediately following operation, in order that the wounds might be

dressed from time to time. Two of them died, one five months after operation, from multiple secondary foci, and the other, four days following operation, from a pyemia, with abscesses involving almost all the vital organs. The two remaining instances of patients with *Staphylococcus osteomyelitis* were treated by the Carrel-Dakin technic without any fatality.

SEVEN CASES OF STAPHYLOCOCCUS OSTEOMYELITIS ILLUSTRATING THE MORE CONSERVATIVE TREATMENT OF THE FULMINATING TYPE

Case 1—*Staphylococcus Osteomyelitis of the Tibia*. T. L., male, age four, was admitted, April 24, 1933, with a three-day history of pain and swelling around the right knee, following an infected blister of the right heel. Temperature 106° F, WBC 25,000, polymorphonuclear leukocytes 96 per cent. The day of admission, after receiving intravenous clyses, the right tibia was drilled, Carrel-Dakin treatment was instituted and a splint applied to the right thigh and leg. Culture of the pus obtained was positive for *Staphylococcus aureus*. Following operation, another focus developed in the upper end of the right humerus, which had to be drained four days later. At this time a blood culture was positive for *Staphylococcus aureus*. Following incision and drainage of the right humerus, a plaster shoulder spica was applied. He remained in the hospital for four months, being discharged August 15, 1933. At the time of discharge the wound over the tibia was still draining. Unfortunately, he never returned to the Follow-Up Clinic.

COMMENT—This case illustrates that the primary O11 treatment of the osteomyelitis of the humerus was followed by prompt healing, while the Carrel-Dakin treatment of the tibia was not.

Case 2—*Staphylococcus Osteomyelitis of the Os Calcis*. I. P., female, age nine, was admitted, July 15, 1933, with a three-day history of pain in the right heel. Temperature was 105° F. Two days later, the soft tissues over the right heel were incised. A blood culture at this time was positive for *Staphylococcus aureus*. Following operation the temperature remained high. Four weeks later, the os calcis was split and a plaster encasement applied. This was continued for three months, at which time the wound was healed. She was discharged December 3, 1933. When seen in the Follow-Up Clinic, one year later, the wound had remained healed.

COMMENT—This case illustrates conservative treatment of a fulminating case of osteomyelitis, though the O11 treatment was not employed until the os calcis had been opened.

Case 3—*Staphylococcus Osteomyelitis of the Radius, with Multiple Other Foci in Bones*. Pyemia. J. K., male, age eight, was admitted, November 21, 1933, with a 24-hour history of abdominal pain. The physical findings noted were tenderness and spasm in the right side of the abdomen. Temperature, 104° F, WBC 12,100, polymorphonuclear leukocytes 70 per cent. For two days, the patient was observed in the hospital and then an appendectomy was performed. The appendix was not diseased. The day following this operation, pain was complained of in the left wrist and, four days later, the wrist was incised and drained. Culture from the pus obtained was positive for *Staphylococcus aureus*. At this time the blood culture was also positive for the same organism. Following this, foci developed in the proximal end of the right tibia, the proximal end of the right femur, the proximal end of the left tibia and the distal end of the left humerus. Each focus was incised and drained and splints applied to the extremities affected. Two and one-half months after admission, he developed a unilateral empyema and a purulent otitis media. Cultures from both were positive for *Staphylococcus aureus*. After four and one-half months, the temperature dropped to normal and remained so. The boy remained in the

hospital for eight months more. On discharge, December 16, 1934, all wounds were healed. When seen in the Follow-Up Clinic, four years later, the only deformity was a fusion of the right hip, with two inches' shortening of the right lower extremity.

COMMENT —This case illustrates an osteomyelitis with pyemia which recurred. Though the Orr technic was not then employed, the involved limbs were immobilized with plaster splints and the fluid balance of the body was kept up.

Case 4 —*Staphylococcus Osteomyelitis of the Left Tibia*. N. W., female, age two and one-half, was admitted, April 28, 1935, with a two-day history of pain around the left ankle. Temperature 104° F, WBC 11,500, polymorphonuclear leukocytes 85 per cent. Twenty-four hours following admission, her fluid balance having been adjusted, the lower end of the left tibia was drilled, the wound lightly packed with vaselined gauze, and a plaster encasement applied. The blood culture at this time was positive for *Staphylococcus aureus*. The Orr method of treatment was continued for two months, when a sequestrectomy became necessary. A month following this, the child was discharged, September 21, 1935, with the wound healed. She has not returned to the Follow-Up Clinic.

COMMENT —A case of the fulminating type of osteomyelitis, with a bacteremia, treated by the Orr technic without further foci in either bone or soft tissues.

Case 5 —*Staphylococcus Osteomyelitis of the Tibia*. R. P., male, age five, was admitted, March 18, 1938, with a three-day history of pain in the right leg. There was swelling and tenderness over the proximal end of the right tibia. Temperature 105° F, WBC 11,500, polymorphonuclear leukocytes 80 per cent. The blood culture taken at this time was positive for *Staphylococcus aureus*. Several hours following admission, after the administration of intravenous fluids, he was operated upon. The wound was lightly packed with vaselined gauze and a plaster spica applied to the extremity. Following this procedure, the temperature gradually subsided, so that 20 days later it remained at a normal level. During this period one blood culture was positive for *Staphylococcus aureus*. The Orr method of treatment was followed for five months, when a roentgenogram showed a sequestrum. This was removed and the Orr method continued. Four months later it was necessary to saucerize the old cavity, which was followed by healing.

COMMENT —This patient was treated by means of the Orr technic throughout, though he had a blood stream infection, no other foci developed in either bone or soft tissues.

Case 6 —*Staphylococcus Osteomyelitis of the Right Tibia*. Pyarthrosis of the Right Knee. B. S., female, age 14, was admitted to the Fourth Medical Division, December 22, 1937, with a three-day history of pain and swelling of the right knee. Temperature 104° F, WBC 10,500, polymorphonuclear leukocytes 80 per cent. A provisional diagnosis of acute rheumatic fever was made. She remained on the medical ward for five days, when a definite diagnosis of acute osteomyelitis of the lower end of the right femur was arrived at. At this time, the blood culture was positive for *Staphylococcus aureus*. Her temperature fluctuated daily between 102° and 104° F. On December 28, she was operated upon. A considerable quantity of pus was drained from the soft tissues of the upper end of the right tibia. The periosteum was elevated and pus was found beneath it. The wound was packed with vaselined gauze and a plaster encasement applied to the thigh and leg. The organism cultured from the pus was *Staphylococcus aureus*.

Following the operation, her temperature dropped to about 101° F and remained at this level for two months. The postoperative treatment consisted of repeated blood trans-

fusions and supportive measures, along with immobilization of the extremity by means of a plaster encasement extending to the hip. Several blood cultures were negative. Two months following the operation, the temperature rose to a level of 104° to 105° F. The old wound was opened and further drainage of the tibia was instituted by the removal of some necrotic bone. The wound was lightly packed with vaselined gauze and an encasement applied to the thigh. This was followed by a spread of the infection into the knee joint. The knee joint was then drained by means of two lateral incisions. These wounds were lightly packed with vaselined gauze and a plaster encasement was applied from the toes to the chest. At this time the blood culture was again positive for *Staphylococcus aureus*. Four days following drainage of the knee joint and the application of the plaster spica, the temperature fell to below 100° F and remained there. Several changes of the spica were made and she was discharged, July 2, 1938, with the leg and thigh immobilized. She now has an ankylosed knee joint and there is a small sinus over the upper end of the tibia, which occasionally heals, only to later break down.

COMMENT—This patient was seen, for the first time, in consultation, two months after the initial drainage, when her blood stream became positive for the second time. The case demonstrates the necessity of efficient drainage, as following the incision of the knee joint and the use of complete immobilization, the blood stream infection ceased and the temperature rapidly returned to normal.

Case 7—*Staphylococcus Osteomyelitis of the Left Femur*. T. A., male, age 16, was admitted, September 8, 1939, with a three-day history of pain and swelling of the right index finger. Temperature 102° F, WBC 11,200, polymorphonuclear leukocytes 75 per cent. The right index finger was reddened and swollen over the entire dorsal surface. The day following admission, the finger was incised and drained. However, the temperature remained elevated and, two days later, the patient complained of pain over the lower end of the left thigh. Swelling and tenderness developed over this area and, three days later, the region was incised and drained. Pus was found beneath the periosteum of the lower end of the femur. The wound was packed with vaselined gauze and a posterior molded splint was applied in an attempt to immobilize the leg. Intravenous clyses were given. Cultures from pus of the finger and the thigh were positive for *Staphylococcus aureus*. The culture from the blood was also positive for the same organism. The patient's temperature remained elevated around 104° F and, five days following drainage of the infection of the femur, a plaster spica was applied. Following this, there was a drop in temperature to a level of about 102° F and, eight days later, the blood culture was negative for *Staphylococci*. In the meantime, he had developed an abscess of the right antecubital fossa, which was drained. The right arm was immobilized by means of a plaster encasement. This was followed by a gradual drop in his temperature and gradual improvement in his general condition. Repeated blood transfusions were administered during this period, as well as intravenous clyses. Three months following operation, the encasement was removed, and a month later the patient was discharged. At the present time there is slight drainage from the wound in the thigh. He also has a chronic osteomyelitis of the phalanx of the finger.

COMMENT—This case demonstrates the fulminating type of osteomyelitis with a positive blood stream infection, where there was fairly rapid improvement without metastases to other bones, following the employment of the Oir treatment.

Of the cases of *Streptococcus* infection (Table IV), seven patients, two of whom had a pyarthrosis of the hip, were treated by immobilization of the

involved limb in a plaster encasement immediately following operation, with no fatalities. Two others, who had plaster encasements applied within two weeks following operation, recovered. In the cases of five patients whose limbs were immobilized in molded splints following operation, one died on

TABLE IV
LOCAL TREATMENT OF STREPTOCOCCUS CASES

Procedures	No of Cases	No of Deaths	Cause of Deaths
Orr technic	7	0	
Encasement immobilization 2 wks after operation	2	0	
Immobilization in splints after operation	5	1	Twelve days after operation—emboli with gangrene of feet
No immobilization	3	1	Seven days after operation—from old lung abscess
Encasement immobilization—no operation	4	0	
Totals	21	2	

the twelfth postoperative day from multiple emboli of the vessels of the lower extremity. In three cases, no immobilization was used at all, one of these patients died of a lung abscess which was apparently the portal of entry of the blood stream infection. In four instances, two of which were pyarthroses of the hip, the lesions resolved without operation, the limbs being merely immobilized in plaster, following aspiration of the effusions.

TWO CASES OF STREPTOCOCCUS OSTEOMYELITIS ILLUSTRATING THE MORE CONSERVATIVE TREATMENT OF THE FULMINATING TYPE

Case 1—Streptococcus Osteomyelitis of the Tibia. B. K., male, age one and one-half, was admitted, January 2, 1933, with an eight-day history of pain and swelling of the right leg. These symptoms were preceded by an upper respiratory infection. On admission, there was considerable swelling over the proximal third of the right tibia. Temperature 105° F, WBC 18,000, polymorphonuclear leukocytes 80 per cent. A blood culture taken on admission was positive for hemolytic Streptococcus. Twenty-four hours after admission, the soft tissues over the proximal end of the tibia were incised and drained. Thin pus was found beneath the periosteum. The bone was not drilled. Following the operation the leg was immobilized by means of a posterior plaster splint. The patient's clinical condition gradually improved and, 14 days later, the temperature reached a normal level. Within six weeks the wound was healed. The boy was discharged, February 17, 1933, but he did not return to the Follow-Up Clinic.

COMMENT—A case of Streptococcus osteomyelitis with blood stream infection, treated by drainage of the focus and immobilization of the limbs by means of plaster splints.

Case 2—Streptococcus Osteomyelitis of the Femur. F. G., female, age 14 months, was admitted, February 6, 1933, with a two-day history of pain in the right thigh. Three weeks previously she suffered from a "cold" and her mother stated that she had had no appetite since. On admission, there was tenderness over the distal end of the right femur.

Temperature 104.8°F , WBC 26,600, polymorphonuclear leukocytes 78 per cent. A blood culture taken at this time was positive for hemolytic *Streptococcus*. On the day of admission, the soft tissues over the lower end of the femur were incised, after the fluid balance had been adjusted, but no pus was encountered. The bone was then drilled and a few drops of thin purulent material obtained. Carrel-Dakin tubes were placed in the wound and the leg immobilized by means of a posterior plaster splint. Following this procedure, her postoperative course was characterized by a high temperature and complicated by ulcerations of both buttocks. However, at the end of a month, the temperature had reached a normal level and she was allowed to leave the hospital, April 30, 1933. At that time, she still had a draining sinus. She was seen at intervals during the ensuing year and was admitted to the hospital 13 months later with a persistent sinus. The distal end of the femur was then operated upon, employing the Orr technic, and the wound healed within six weeks. She has been seen at intervals since and the wound has remained healed.

COMMENT—A case of *Streptococcus* osteomyelitis of the femur, with blood stream infection, treated by incision and immobilization of the limb in plaster splints, with Carrel-Dakin treatment of the wound. (For other examples the reader is referred to the case histories of *Streptococcus* pyarthrosis of the hip joint.)

The results of conservative treatment of five patients with *Streptococcus* pyarthrosis of the hip joint were most encouraging. In all of them, the joints were first aspirated. In three of these cases plaster hip spicas were applied as well, one case had to have the joint drained two months later, but the other two recovered without operation. In another case, traction was used, following an aspiration, until the twentieth day, when the joint was drained and a plaster hip spica was then applied. The fifth case was an infant of seven months, in which the joint was aspirated but later a drainage was necessary. All of these five patients recovered. One of them could not be followed. The other four obtained functioning hip joints, though in one instance, motion was restricted and in another, there was slight shortening of the limb.

FIVE CASES OF STREPTOCOCCUS PYARTHROSIS OF THE HIP JOINT ILLUSTRATING A MORE CONSERVATIVE FORM OF TREATMENT

Case 1—*Streptococcus* Pyarthrosis of the Right Hip Joint. L. L., male, age one, was admitted, December 14, 1935, with a seven-day history of irritability, fever, anorexia and rash. For four days prior to admission he had not moved his right leg. There was swelling of the right hip region and a generalized macular rash. Temperature was 101°F , WBC 14,000, polymorphonuclear leukocytes 52 per cent. The right leg was placed in traction with a one pound weight. For two weeks, the temperature remained around 101°F . The swelling around the right hip joint gradually increased. Then the hip joint was aspirated and 25 cc of cloudy, straw-colored fluid was obtained. Hemolytic *Streptococci* were cultured from the fluid. The blood culture at this time was negative. Five days later, the fluid aspirated from the hip joint was considerably thicker in consistency, and incision and drainage was decided upon.

At operation, the joint was drained posteriorly, the wound in the soft parts lightly packed with vaselined gauze, and a plaster hip spica was applied. Eight days following the incision and drainage, the temperature dropped to normal and remained down. The encasement was removed after four weeks. The wound was healed. At this time, there was marked limitation of motion of the hip joint. The patient was discharged March 6,

1936 One year following discharge from the hospital, both legs measured the same length—37.5 cm. There was very slight loss of extension but no other loss of motion.

COMMENT—A case of hemolytic pyarthrosis of the hip joint in which drainage was delayed until the exudate became purulent. Treated by means of the Ori method, recovery with little loss of function.

Case 2—Streptococcus Pyarthrosis of the Right Hip Joint. F. K., female, age 5, was admitted to the Ear, Nose and Throat Service, March 3, 1936, with a two weeks' history of fever and a discharging ear, which followed an attack of measles. On physical examination spasm of the muscles about the right hip was noted. Temperature was 105° F, WBC 13,600, polymorphonuclear leukocytes 60 per cent. The hip joint was aspirated and a small amount of serous fluid was obtained. Culture of this fluid was positive for *Streptococcus haemolyticus*. The right hip was encased in a plaster spica. Following the application of the spica the temperature gradually dropped, during an eight-day period, from a daily level of 105° to around 100° F. The spica was changed at intervals of about two weeks, for eight weeks, when the immobilization was discontinued. At this time a roentgenogram showed "destructive arthritis of the right hip joint characterized by marked osteoporosis of the head and neck of the femur, diminution of the joint space and epiphyseal space between the head and neck." On discharge from the hospital, June 6, 1936, there was marked loss of motion of the hip joint. Examination in the Follow-Up Clinic, one year following discharge, showed 25 per cent loss of extension at the hip joint, 40 per cent loss of flexion, and 10 per cent loss of abduction. There was no shortening of the extremity.

COMMENT—This case demonstrates the treatment of Streptococcus pyarthrosis of the hip joint by means of aspiration and immobilization.

Case 3—Streptococcus Pyarthrosis of the Right Hip Joint. P. M., female, age four, was admitted, May 24, 1936, with a four-day history of pain in the right hip and a discharge from the left ear. Two weeks previously, she had had a sore throat and a generalized body rash which subsided after two days' duration. On admission, the child was acutely ill. Temperature 105° F, WBC 12,500, polymorphonuclear leukocytes 80 per cent. She had an acute pharyngitis and a bloody discharge from the left ear. The right hip was held in flexion, there was marked resistance to any motion, a slight amount of swelling was present. A blood culture taken at this time was positive for *Streptococcus haemolyticus*. A small amount of blood-tinged fluid was aspirated from the right hip joint. Culture of this fluid showed *Streptococcus haemolyticus*. A plaster spica was applied, immobilizing the hip joint.

The patient remained critically ill. Temperature level of around 105° F. She was given several small blood transfusions. A week later, the blood culture was still positive for *Streptococcus haemolyticus*, but the child's general condition was improved. The spica was removed at this time and the hip aspirated again. A new plaster spica was applied. Two weeks later, the temperature had dropped, her general condition was improved, and the blood culture was negative for Streptococci. The plaster spica was changed on several occasions, and three months later was removed for good. At that time roentgenograms showed irregularity of the head of the femur, with evidence of some destruction of the femoral head and neck. Since then, there has been no recurrence of the condition in the hip joint. Both legs are approximately the same length. There is slight loss of both abduction and extension of the right hip.

COMMENT—This patient illustrates the result following an acute streptococcus infection of the hip joint treated by aspiration and immobilization.

Case 4—*Streptococcus* Pyarthrosis of the Hip Joint J M, male, age seven months, was admitted, January 3, 1933, to the Pediatric Service, with a twenty-four-hour history of cough, vomiting and continuous crying. The baby had had several "crops of boils." He was well nourished, weighing 16 lbs. No abnormal physical findings were noted, except for a reddened pharynx and a furunculosis of the scalp. Temperature was 100° F. A tentative diagnosis of nasopharyngitis was made. The child remained on the Pediatric Service for four and one-half weeks, and apparently recovered from both the furunculosis and the nasopharyngitis. However, at this time the child became irritable, and there was a daily rise of temperature to 103° or 104° F. A diagnosis of osteomyelitis of the upper end of the left femur was made. On aspiration of the left hip joint, a seropurulent exudate was obtained. W B C 21,000 at this time, polymorphonuclear leukocytes 80 per cent. The blood culture was positive for hemolytic *Streptococci*. Culture from the hip joint was also positive for the same organism. The limb was placed in traction with three pounds' pull. Several small blood transfusions were given. Two other aspirations were done during a period of two and one-half weeks. The temperature remained elevated with daily fluctuations from 101° to 104° F.

At the end of two and one-half weeks, a fluctuant area appeared over the lateral side of the left hip, the hip joint was incised and drained. Thick pus was obtained. Following operation, the leg was again placed in traction. There was a slight drop in the daily temperature curve. One week later, a roentgenogram showed osteomyelitis of the terminal phalanx of the left middle finger. The finger was splinted. For two weeks the condition of the patient remained about the same. Several small transfusions were given. He then developed bilateral, purulent otitis media, which drained spontaneously. Culture from the ears was positive for *Streptococcus haemolyticus*. Following this the temperature gradually dropped to a daily level of around 100° F, there was a gradual diminution of the amount of drainage from the hip joint, and the weight increased. Seven weeks following the incision and drainage, a plaster spica was applied. This was continued for five months. On discharge from the hospital, February 3, 1934, the wound in the hip region was healed and there was some motion present in the joint. Unfortunately, the patient never returned to the Follow-Up Clinic.

Case 5—*Streptococcus* Pyarthrosis of the Right Hip Joint P B, female, age 17 months, was admitted, May 7, 1936, with a history of swelling of the right thigh and a perirectal abscess. Two days following admission, the perirectal abscess was drained. Hemolytic *Streptococci* were cultured from this abscess. One week later, the right hip was aspirated. No pus was obtained. However, the swelling continued and, two weeks later, thick, yellow pus was aspirated from the right hip joint. The joint was then incised and drained. Culture of the pus obtained was positive for hemolytic *Streptococci*. Following the operation, the extremity was placed in traction for two weeks. A plaster hip spica was then applied. This treatment was continued for two months and, at the end of this time, the wound was healed. One month later, October 21, 1936, the child was discharged.

Six months following discharge, there was only slight limitation of abduction of the hip joint. All other motions were complete. A roentgenogram at this time showed "extensive destruction of the head of the right femur." Two years following discharge, there was no loss of motion at the right hip joint. However, there was 2 cm shortening of the extremity.

CONCLUSIONS

(1) When death occurs in cases of hematogenous infections of bones or joints, it appears to be due to either a septicemia or a pyemia, the result of the bacteremia and is not due to the lesions within the bone or the joint.

(2) Hemic infections due to the *Streptococcus* behave differently from

those due to the *Staphylococcus*, as shown by the manifestations of both the bacteriemia and the local lesion

(3) In consequence, every attempt should be made to recognize the causative organism before treatment is begun

(4) In treating cases of hematogenous osteomyelitis and pyarthrosis, more attention should be paid to the general condition of the patient than has been done in the past and, before operation is undertaken upon the local lesion, the normal physiologic balance of the body should be established, through the use of intravenous saline and glucose solutions and transfusions

(5) The local lesions should not be drained by incision until an abscess is formed or frank pus is found to be present, though in cases of pyarthrosis the joint may be aspirated to relieve the tension within its capsule. Lesions due to the *Staphylococcus* should be drained as soon as the patient's bodily condition warrants it. Those due to the *Streptococcus* can be drained when a purulent exudate has formed

(6) In the treatment of both acute osteomyelitis and pyarthrosis, complete immobilization of the limb with infrequent dressings of the wound has proved of benefit—by preventing the spread of infection, by avoiding contamination with secondary organisms and through promotion of healing. Further, because of the relaxation of the surrounding muscles and the assurance it gives the patient of not being hurt, immobilization of the limb has greatly benefited the general morale of the individual. We have often found that the pyrexia rapidly subsides following the application of a plaster encasement

(7) By employing the procedures which have been recommended, we have shown an improvement in our mortality

(8) The pyarthroses which have been treated by means of the Orr method have shown far better functional results than those treated by other methods

REFERENCES

- ¹ Ottley, Drewry. *The Life of John Hunter*. Philadelphia, Haswell, Barrington and Haswell, 1839
- ² Starr, C. L. Acute Hematogenous Osteomyelitis. *Arch Surg*, 4, 567-587, May, 1922
- ³ Orr, H. Winnett. *Osteomyelitis and Compound Fractures and Other Infected Wounds, Treatment by the Method of Drainage and Rest*. St. Louis, 1929
- ⁴ Fraser, John. Acute Osteomyelitis. *Brit Med Jour*, 2, 539, September 22, 1934
- ⁵ Pyrah, L. N., and Pam, A. B. Acute Infective Osteomyelitis. *Brit Jour Surg*, 20, 590-601, April, 1933
- ⁶ Robertson, D. E. J. Bone and Joint Surg., 20, 35, January, 1938
- ⁷ Beekman, Fenwick. Acute Hematogenous Osteomyelitis. *ANNALS OF SURGERY*, 88, 270-296, August, 1928
Idem. Acute Hematogenous Osteomyelitis. *Bull. N. Y. Acad. Med.*, Second Series, 6, 792-807, December, 1930

DISCUSSION —DR FRANK L. MELENEY (New York) I would just like to speak of one phase of Doctor Beekman's paper, namely, the question of septicemia. In most of these cases, the organism gets in through a portal of entry that is hardly noticeable and then the infection becomes established in

the bone. The original focus of distribution is not the focus from which the septicemia is maintained. The bone focus becomes the major focus and the continuing septicemia is due to distribution of the organisms from the bone focus. So, in cases of osteomyelitis with septicemia, the bone focus is of prime importance. I agree entirely, however, that the septicemia has to be treated first, for if the distribution is not checked, metastatic lesions soon develop in the internal organs—kidneys, liver, spleen or other bones.

In hemolytic *Streptococcus* osteomyelitis with septicemia, we now have sulfanilamide, which can control the septicemia in most cases without, however, clearing up the bone focus, which later has to be operated upon. For the *Staphylococcus aureus*, on the other hand, drugs are not at present available, although there is some evidence that the new pyridine derivative of sulfanilamide may play a part. During the last few years, potent bacteriophage has been available for the *Staphylococcus* septicemias and we have found it particularly applicable in the cases with bone or joint involvement. We believe that its action in septicemia is chiefly a clearing of the blood stream and an inhibition of the distribution of the organisms from the bone focus.

Bacteriophage has been in disrepute in times past and I believe that disrepute is due to two things. In the first place, to the too sanguine claims of d'Herelle, its chief exponent, and in the second place, to lack of potent phage. A test for adequate potency has been developed recently in our laboratory. During the last two years, we have been using particularly potent phage and our results, not only in osteomyelitis septicemias but in other cases of *Staphylococcus* septicemia, have been greatly improved.

Our 36 cases of septicemia have been divided into two groups—namely, the 15 earlier cases, which were treated with phage considered potent because it cleared the culture, and the 21 later cases, in which the phage had been subjected to the double potency test, in other words, phage which not only cleared the culture, but which prevented subsequent growth when the cleared culture was transplanted on a blood agar plate.

Eight out of 36 cases of septicemia had metastases to the bones, which then became distributing foci. Two were in the early group, and both of these died. The other six were in the later group, and all recovered. In one of the early group, and in three of the later group, there was also joint involvement.

Method of Application—In septicemia, the phage is given intravenously, diluted 1:10 in saline, in gradually increasing doses—0.25, 0.5, 1, 2, 3 and 4 cc., at hourly intervals the first day. If there is no reaction, the dose can be more rapidly increased by 5 cc. increments every 12 hours during subsequent days, up to 25 cc. twice a day and continued until there are two sterile blood cultures. If reactions occur, the dose must be increased more slowly. When the bone focus is opened, phage is applied directly to the lesion once or twice a day either on compresses or through Carrel tubes.

Summary of Final Results—Before October, 1936, our mortality in 15 cases of *Staphylococcus* septicemia treated with bacteriophage was 76.3 per cent. During the next two years, in 21 cases, the mortality was reduced 28.5 per cent. The mortality for the osteomyelitis cases was reduced from 100 to 0 per cent. A small series, to be sure, but I believe significant. In the phage series as a whole, the mortality was 47 per cent, while in a control series in previous years 81 per cent died. We believe that we will be able to reduce the figure still further if we can get our cases earlier and treat them with a doubly potent phage.

DR EDWARD T CROSSAN (Philadelphia) Doctor Beekman and Doctor Sullivan are to be congratulated on their excellent mortality figures and on the end-results they have presented. There is no doubt that the good results are due to the various factors pointed out in their paper. In the first place, adoption of its principles of delay in the operation. Eighty per cent of the deaths in the entire series occurred in those patients operated upon within the first week of the disease. Second, he has called to our attention the importance of differentiation between Streptococcus and Staphylococcus osteomyelitis. The Streptococcus osteomyelitis is a comparatively mild disease, that is, it is not as serious in end-results nor in mortality figures as is the Staphylococcus variety. Third, Doctor Beekman shows that conservative treatment of pyarthrosis is not only time saving and function saving, but also life saving.

DOCTOR BEEKMAN (closing) said that in regard to draining the bone, he has drilled the metaphysis always in fear of damaging the epiphyseal cartilage plate and, in consequence, has found that the drill holes have been two or three inches away from the point at which it was desired to drill. Fortunately, it had not been found necessary to drill in many cases. In three-quarters of the cases of osteomyelitis operated upon, pus has been found beneath the periosteum and when this has been so, Doctor Beekman has gone no farther. If there is no pus found beneath the periosteum, it is usually an indication that the case has been operated upon too early. In such cases Doctor Beekman prefers to make a small trapdoor, but without interfering with the medullary contents of the metaphysis.

Doctor Meleney brought up the question of distribution of bacteria through the blood stream, either from the portal of infection, or from the bone focus. Doctor Beekman said that he had felt more and more, in the last few years, that it is not from the bone focus, but if it is, that affords another reason why one should not operate too soon. For if one does, he will certainly break down the body's defense about that abscess. Doctor Beekman said that, of course, he had tried the old type of phage. It was made from the bacteria of these lesions after they had been draining for some days, weeks or months. Robertson brings out in his observations that the Staphylococcus loses its virulence very rapidly, it is an organism from which antitoxins or good phages should be made in the early periods, while it still retains its virulence. Therefore, if it is possible to reduce Staphylococcus septicemia from 80 to 20 per cent, as Doctor Meleney has apparently been able to do, it is in that direction that one should look in the future for improvement in mortality.

THE TREATMENT OF FRACTURES OF THE NECK OF THE FEMUR BY INTERNAL FIXATION

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THE VALUE of any new surgical procedure cannot be estimated accurately from a small group of cases. This is especially true with respect to fractures of the neck of the femur. Since no one author has reported a very large series of cases, it is essential that each surgeon doing this work should report his results so that a worth while analysis can be made.

Union practically never occurred in these cases prior to 1904, when Whitman proposed his method of treatment. Even since then, the results in this type of fracture have been poorer than the results for any other type of fracture commonly sustained by the human body.

We find, in reviewing the reports of various clinics, that the percentages of union vary from 38 to 65 per cent. In 1929, a committee from the American Orthopedic Association¹ reviewed reports of the leading clinics throughout the country. They found the average of bony union was 50.4 per cent with a mortality of 28.6 per cent. Cleveland and Bosworth² recently reported a very interesting résumé of 40 consecutive cases treated by the closed method at St. Luke's Hospital in New York City. The immediate mortality was 14 per cent. Thirty-eight per cent of the total series obtained bony union. Forty-six and one-half per cent of the patients who lived obtained bony union. The average age of those obtaining union was only 59.5 years. The average period in the hospital for those patients was 122½ days. The average cost to the ward patient was \$671.50, to the private room patient, \$1,000. This did not include special nurses, roentgenologic examinations, operating room charges, or surgeons' fees.

During the last ten years, there has been a concentrated effort by leading surgeons throughout the country to reduce this appalling mortality and percentage of nonunion. From the many reports that are now to be found in the literature, this attempt has been highly successful. Without exception, the method used has been some type of internal fixation.

Any intelligent discussion of this subject must be predicated upon an understanding of certain anatomic and physiologic facts. The head and most of the neck of the femur are intracapsular. The head receives its chief blood supply from blood vessels in the neck of the femur. The remainder comes by way of the ligamentum teres. Therefore, the closer the fracture is to the head, the poorer will be the blood supply to the proximal fragment. This is particularly true if the ligamentum teres has been torn. If one fragment is

avascular or nearly so, the new bone growth must develop solely from the other fragment and, of necessity, this delays the union. It is probably true that the presence of the joint fluid also helps delay union.

Watson-Jones³ states that the union of these fractures is governed by the rules of hyperemic decalcification and ischemic recalcification. Motion at the site of the fracture increases the hyperemic decalcification with absorption of the neck and nonunion. Adequate or complete immobilization is not obtained by external fixation. Watson-Jones further states that the degenerative atrophic arthritis which so frequently occurs following a fracture of the neck of the femur takes place because the head of the femur must revascularize and regenerate by invasion of new blood vessels from the distal fragment. The articular cartilage is less resistant and undergoes degenerative changes when deprived of blood for any length of time and when exposed to the trauma of early weight-bearing. This unfortunate phenomenon was demonstrated in one of our early cases of subcapital fracture, in which we permitted weight-bearing from the first although union occurred at the site of the fracture.

Fractures of the neck of the femur must be divided into two groups. The first group includes those occurring in the neck proper or intracapsular fractures. This is the type in which delayed or nonunion occurs. The second group embraces trochanteric or extracapsular fractures, which practically always heal. These cases have a rich blood supply from both ends of the fragments.

In 1931, Smith-Petersen⁴ perfected his method of treating fractures of the neck of the femur by internal fixation with a specially designed three-flanged nail. Since that time, numerous and sundry gadgets have been devised to obtain similar results. The same basic principle underlies all of the various inventions, that is an attempt to obtain absolute and continued immobilization and a satisfactory anatomic reduction. When these two prerequisites are fulfilled, the fracture should heal as well as any other in the human body.

Originally, the internal nailing operation was confined to the intracapsular fractures. In recent years many more operators are using the nailing procedure for trochanteric fractures, not primarily to obtain union, but because of the markedly shortened period of hospitalization, the absence of ankylosed knees and ankles, and the absence of the long chain of potential complications which may occur to an aged individual who is kept bedfast for a period of three or four months.

These facts were demonstrated very clearly to us by two male patients who were admitted to the hospital with identical fractures on the same day. They were both in good health and of approximately the same age. One was a farmer and the other a business man. The farmer was treated by the usual methods which required his being in bed in the hospital for a period of three months, followed by an additional period of three weeks in which he was becoming ambulatory on crutches. At one time, while he was in the hospital, the skin was broken by skin traction requiring some special surgical

care At another time, he developed an atelectasis and was quite sick for several days He had a great deal of difficulty in sleeping and was pretty well worn out when his period of immobilization was over Added to his disability was a stiff knee and ankle with the usual swelling of the extremity when on his feet Bony union occurred at the end of three months with the fragments in good position It was nine months from the time of his fracture before he was really back to normal and able to carry out his duties on the farm

The other patient, the business man, had heard about internal fixation and requested that we carry out this procedure in his case His operation was not attended with any difficulties He was in a wheel chair within a week and was able to handle himself well on crutches at the end of two weeks at which time he was discharged from the hospital He was back in his office at the end of three or four weeks from the time of his accident This man continued to look after his business affairs during the entire period of his convalescence At the end of three months he was in excellent physical condition and had maintained his normal weight There was no stiffness of the knee or ankle and no swelling of the lower extremity He obtained union in three months as did the man who was kept hospitalized

Comparing these two cases, it is obvious that the operative method is the procedure of choice The first man was hospitalized for almost four months, he was faced with a large hospital bill, was considerably under paid from his experiences in the hospital, and it was nine months before he could resume his normal activities The second man was in the hospital three weeks and was away from his duties at his office for only one month Since that time we have operated upon all trochanteric fractures routinely

Trochanteric fractures require the observation of certain important details We consider the Moore nails best adapted to this work because of the lessened danger of fracturing the remaining shaft of the femur Furthermore, the nails must be inserted at a slightly lower level than would be desirable for an intracapsular fracture This is done to obtain a more solid attachment for the nails in the distal fragment There is less likelihood of having the nails bend or pull out There is also less shearing force on the nails from weight or muscle pull In many cases the fracture extends through the shaft to the outer side of the trochanter so that in order to get into the distal fragment one may have to insert the nail as much as two or two and one-quarter inches below the base of the trochanter We have found it advisable to drill the openings for the Moore nails with an ordinary bone drill which is slightly smaller than the nail itself This procedure greatly facilitates the insertion of the nails

Preoperative Care—When the patient comes to the hospital he is placed in an ordinary bed, and a Buck's extension is applied to the broken limb with about ten pounds of traction Sand bags are placed on either side to prevent movement and external rotation Small doses of morphine are given for pain intravenous glucose and blood transfusions are given until the patient's blood

count is normal, and his normal water balance established. The operative procedure is not attempted until the patient is eating normally and taking sufficient fluids by mouth for his normal requirements. In other words, the patient must be returned, as nearly as possible, to his normal condition prior to the accident before the operation is attempted. In our experience this will require from seven to ten days, and in some cases even a few days longer. If immediate operation is carried out, unquestionably there will be an unnecessarily high mortality credited to the procedure.

Operative Technic—The skin is prepared the night before the operation and sterile dressings applied. A mild sedative is administered the morning of the operation. The patient is transported to the operating room in his bed. A low spinal anesthesia is administered. He is then lifted to the operating table and the fracture reduced by the Leadbetter⁵ technic. Both feet are attached to the foot pieces of the Albee table. Both legs are brought out to about 30° abduction and the affected limb placed in full internal rotation. Anteroposterior and lateral roentgenograms are taken with a portable unit. While these are being developed, the patient is draped and a lateral incision is made which exposes the trochanter and the proximal end of the shaft. If the roentgenograms show the fragments are in good position (which is usually the case), we are ready to proceed with the first part of the operation. We do not feel that any elaborate apparatus is necessary for finding the head of the bone. A towel clamp is placed over Poupait's ligament midway between the symphysis pubis and the anterior superior spine. This will be approximately over the head of the femur.

In those cases in which the Smith-Petersen nail is used, four or five Kirschner wires are drilled into the head of the femur. These enter at various levels. This is done for two purposes. First, to make new openings into the head of the femur for additional blood supply, and second, we desire to pick the wire that is best situated for the insertion of our nail. After this has been accomplished, a sterile sheet is placed over the patient and operative field. Roentgenograms are taken again in both anteroposterior and lateral views. Needless to say, the close cooperation of the personnel of the Roentgenologic Department is highly desirable. The best wire is chosen and the others extracted, so that they will not interfere with the entrance of the nail. On a few occasions we have had difficulty with the nail wandering as it was threaded over the guide wire. This results in a bent wire which offers considerable difficulty on extraction. To combat this, we simply insert the nail beside the wire. Occasionally, difficulty will be encountered by the projecting portion of the guide wire being deflected by the hammer. To correct this, we drill an additional wire about one-half inch away but on the same plane and use this as an additional guide.

The surgeon who is attempting this operation for the first time should be warned that the roentgenograms magnify the actual distance from the shaft to the head of the femur. There are many unique methods devised to estimate this discrepancy. In our experience, the actual distance is about

80 per cent of the measurement on the film. Probably the easiest way to calculate this is to estimate it from the wire which is being used as a guide. The length of the wire is known. We measure the amount that protrudes and then knowing the length of the remainder estimate the length of nail necessary. If the nail enters the acetabulum, it should be pulled back into the head to avoid permanent damage to the joint.

After the nail is inserted, the Kirschner wire is extracted and the nail driven in tight so that the fragments are impacted. A sterile sheet is again thrown over the patient and further roentgenograms taken so that we can be certain that our nail is in proper position and the fracture properly reduced. As soon as this is ascertained, the wound is closed.

As an operator gains experience, the procedure becomes quite simple. With the foot in full internal rotation the neck of the femur is in the horizontal plane. A towel clamp is placed midway between the anterior superior spine and the symphysis pubis. This gives the approximate location of the head. If the nail is started an inch to one and one-half inches below the base of the trochanter at an angle of 45° with the shaft, directing the point toward the towel clamp and on a horizontal plane, the nail will enter the head in the majority of cases.

We have found in an occasional case in which it was necessary to expose the joint and the fracture line, that the following incision gives an excellent exposure.

The usual lateral incision is extended from the trochanter for a distance of about three inches upwards and in front of the anterior superior spine of the ilium. The muscle fibers attached to the anterior base of the trochanter and the upper two inches of the shaft are cut and retracted. The capsule then comes into view. A short transverse incision is made in the base of this. A second one is made from the base to the acetabulum in the longitudinal plane. The whole neck, fracture line and head of the femur will then be exposed. The fracture can then be accurately reduced and fixed with the nail by direct vision.

Precautions to Avoid Shock—The observation of a few simple rules should obviate practically all symptoms of shock during the operative procedure. Because of the necessity of considerable delay in the taking and developing of the roentgenograms, the operation must, of necessity, consume in the neighborhood of one hour's time. A general anesthesia of this duration in an aged individual is not desirable. Local anesthesia, even in the best hands, will be accompanied by a certain amount of pain. In our experience a low spinal anesthesia is the one of choice. It is not painful to administer, the anesthesia is complete, and can be used over a prolonged period of time without adding to the morbidity. Intravenous 5 per cent glucose is started immediately after the patient is placed upon the operating table. The patient is wrapped in warm blankets not only on the trunk but on the unaffected limb and from the knee down on the affected limb. Over the blankets are placed hot water bottles which are retained in position by bandages. In

this way we can conserve the patient's body heat, the dissipation of which we feel contributes considerably to the production of shock. If there is a marked fall in blood pressure, adrenalin or epinephrine is given hypodermatically. Considerable care is exercised to insure the loss of as little blood as possible. The wound is never left exposed during the waiting periods for the developing of the roentgenograms, hot saline packs being placed in the depths of the wound. It has been our experience that if these precautions are taken, there will be practically no shock whatever regardless of the patient's age. In the majority of cases the patient will sleep peacefully through the operation and will have to be awakened to be advised that the operation has been completed.

Postoperative Care—At the termination of the operation, the patient is placed in a warm bed with a sand bag on either side of the leg or with a short board nailed to a shoe or bedroom slipper to hold the foot erect and prevent external rotation. He is encouraged to take water and food as though nothing had happened. The next day the patient is propped up in a sitting position in bed. In the next day or two he is placed in a wheel chair. As soon after this as he is strong enough he is given crutches and walking is started. We find that in the average case this will be a week or ten days from the time of the operation. The patient is then ready to be discharged from the hospital unless there is some other complication requiring further hospitalization.

The Question of Weight-Bearing—The first three or four of our early cases were permitted weight-bearing before union had occurred. One of these cases had some degenerative arthritis around the head. Another case was one in which the patient wore a plaster encasement for three months because the pin extended into the acetabulum. After the second pin was placed in the hip she was permitted weight-bearing. This may have had something to do with the nonunion. Since the first few cases, it has been our rule never to allow weight-bearing until solid union can be demonstrated roentgenologically. By this we mean that bony trabeculations must be seen traversing the fracture line. This usually requires from four months to a year. We believe that this is one of the principal causes for nonunion and arthritis. The patient is permitted normal motion of the knee and ankle within the first week after the operation. Full range of motion in the hip is not encouraged for about six weeks. It is probable that the majority of the patients move the extremity through the normal range of motion within the first few weeks. Apparently it does no harm as the flanged nail prevents rotation of the head on the neck.

The Use of External Fixation or Plaster Spicas—We use absolutely no type of external fixation plaster spicas in the intracapsular fractures. Apparently, the pin gives all the support that is necessary. In trochanteric fractures, unless the fracture line is close to the base of the neck, we feel that it is possibly a little safer to use a short hip spica for about six weeks because of the danger of the head of the nail or Moore pins being pulled through the thin shaft. In our series, there was only one exception to this rule. This was in a man, age 83, who left the hospital ten days from the

time of operation with the promise that he would do nothing more than sit in a wheel chair for a period of six to eight weeks. His family physician wrote me about eight weeks later stating that the patient had been walking without a cane or a crutch from the fourth week. At the end of five months, he fell down a long flight of cellar steps, badly bruising himself. Roentgenograms taken of the hip revealed it in perfect position and perfectly healed. Apparently the wires had not even bent with his walking at the end of a month's time.

Indications for Operation—We feel that we are justified in operating upon any patient whom we believe will live a month or six weeks from the time of operation, if for no other reason than to relieve him of his pain. We believe that any patient who has survived the original shock of his injury and has improved to the point that he is taking fluids freely and is eating normally, will survive the operation without mortality, barring unpredictable accidents or complications. In our series we operated upon all cases that we saw, the ages varying from 39 to 95.

Advantages of Internal Fixation—In reviewing the literature, we found that the mortality for any of the closed methods varied from 15 to 40 per cent. The average mortality for internal fixation was less than 10 per cent. The highest percentage of union reported by the closed method was 65 per cent, the majority being 50 per cent or less. The average percentage of union by internal fixation was above 80 with many over 90. The period of hospitalization is very materially decreased, thereby markedly decreasing the cost of hospitalization. When the closed method is used, a large percentage of aged patients develop senile dementia or other cerebral changes. There is much less danger of this complication when early discharge from the hospital is made possible by the use of internal fixation. A very important factor is the complete cessation of pain following the operation.

The Question of Removal of the Nails After Union Has Occurred—We feel that after union occurs in young individuals, the nail should be removed. To date, we have removed only two, and in both cases the nails still fitted snugly in their grooves. Roentgenologically, no changes could be seen, and both had been in over a year. In the older individuals, particularly those past 75, unless the nail gives trouble, we do not think it is necessary to remove it. With the development of Venable or "vitallium" nails, which theoretically cause no electrolysis or change in the bone, it may be unnecessary to remove them at any age. We shall be able to reach a definite conclusion only after watching these cases over a long period of time.

IMPORTANT POINTS IN THE TREATMENT OF FRACTURE OF THE NECK OF THE FEMUR BY INTERNAL FIXATION

(1) Operation should not be undertaken for at least seven to ten days after the time of the accident or until normal physiologic functions have been restored.

- (2) A minimum degree of anesthesia should be used We prefer a low spinal
- (3) The fracture is reduced by the Leadbetter technic
- (4) Intravenous glucose should be administered during the operation and the patient wrapped with blankets and hot water bags to prevent loss of body heat
- (5) The nail should be placed one inch below the base of the trochanter and enter well into the head
- (6) Both lateral and anteroposterior roentgenograms should be taken during and after the operation
- (7) The patient should be encouraged to be ambulatory on crutches as soon as possible
- (8) There should be absolutely no weight-bearing until solid union is demonstrated roentgenologically

APPRAISAL OF THIS SERIES OF 25 CASES

The age incidence varied from 39 to 95, the majority of the patients being past the age of 70 Seventeen were intracapsular fractures and eight trochanteric The first case was operated in January, 1936 All cases have been followed since the time of operation The end-results are known All



FIG 1—Case 8 After the first operation showing the rotation of the head

of the cases of trochanteric fractures have healed Of the intracapsular fractures, two patients have died, one from hemiplegia five months after the operation Until the time of her death she was getting along very nicely on crutches and was apparently obtaining union The second died six months after operation from cardiovascular disease He had no pain, had normal range of motion, but had been bedridden for two months before his death because of his terminal diseases There has been one death in the trochanteric fractures This patient died of apoplexy five months after operation Union was complete, as shown roentgenologically six weeks before her death

This, then, leaves 15 cases of intracapsular fracture which have lived Two of the 15 cases have not had satisfactory results The first developed nonunion and sequestration of the head This was the case in which the nail entered the acetabulum The patient was immobilized in a plaster spica for three months, at which time the nail was removed and another shorter nail inserted Weight-bearing was permitted at this time The neck has gradually absorbed, the nail is eroding up through the head into the acetabulum The patient is still walking around but has some pain Further surgical treatment will be necessary

The second case was a subcapital fracture with a rather marked comminution of the neck with pieces of loose bone between the two main frag-

ments At the original operation it was impossible to obtain a satisfactory reduction At the time the operation was completed, an anteroposterior view showed the pin in good position but the lateral was not clear The wound was closed and a roentgenogram the next day revealed the fact that the pin caught only a little of the posterior portion of the head and that the head

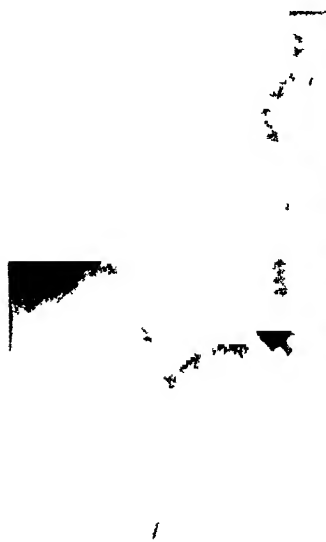


FIG 2—Case 8 After the second operation



FIG 3—Case 8 The neck is mostly absorbed



FIG 4—Case 8 After the Colonna operation



FIG 5—Case 2 Subcapital fracture healed



FIG 6—Case 9 Subcapital fracture healed



FIG 7—Case 15 Subcapital fracture healed

itself had rotated Unquestionably, the ligamentum teres was torn in this case Ten days later a second operation was performed, with wide exposure of the joint and even then a nail could not be satisfactorily placed so as to reduce the fragments, there being a short distance of gaping between the two We believe this would have been an ideal case for a bone graft Several months later the patient developed an aseptic inguinal abscess which was

drained. Still later, a septic infection developed in the sinus tract which extended into the joint. The neck was gradually absorbed and the head became a sequestrum. This necessitated the removal of the nail and the sequestered head, with the performance of a Colonna reconstruction operation to obtain a stable hip. The patient was kept in a plaster spica for a period of four weeks. At the present time he has about normal flexion and extension, but no abduction. There is three-fourths of an inch shortening. There is practically no pain. He has an excellent result.

Reviewing these cases, I believe that Case 1, in which the nail entered the acetabulum, was an example of a severed ligamentum teres. Case 13, in which we used a bone graft, had a severed ligamentum teres. Also, in Case 8, described in the preceding paragraph, the ligamentum teres was severed. In a fourth case, recently operated upon but not included in this series, the ligamentum teres was severed. All of these had subcapital fractures. They accounted for the two cases of nonunion in this series, and unquestionably would have accounted for the third if a bone graft had not been used. The patient just recently operated upon had a bone graft used for fixation. A surgeon should suspect that the ligamentum teres is severed in any case of subcapital fracture in which the head tends to rotate when a pin is introduced. While we have only had this experience in a few cases, I believe that it is wise to use a bone graft instead of metal fixation when there is a suspicion that the ligamentum teres is severed.

Summarizing the results obtained in the 25 cases of this series we note that there have been eight trochanteric and 17 intracapsular fractures. One of the trochanteric fractures died five months after operation, but union had already occurred. Two of the intracapsular fractures died after a five-month period but before union had occurred. Two cases had nonunion with a dead head. The remaining 13 have solid bony union. All of the trochanteric fractures obtained union. Since we are not attempting to improve our results as far as union is concerned in the trochanteric fractures, we will only consider the intracapsular fractures. Out of the 17 intracapsular fractures, solid bony union was obtained in 76 per cent of all the cases. If the two patients who died after a five-month period are eliminated, bony union occurred in 86.6 per cent of the remainder. There were no cases of operative infection. There was one case in which an aseptic abscess developed several months after the operation which, in turn, was infected through the sinus tract. There was no operative mortality. The closest death to the time of operation was five months. Of the 25 cases, 22 are still living.

Statistics of Other Authors—Watson-Jones³ reports a series of 64 cases. His first series was composed of 29 cases with 79 per cent bony union. The next group was composed of 35 cases with a 91 per cent bony union. The total operative mortality was 6 per cent.

Willis Campbell⁶ reports a series of 35 cases, 19 of which had been under observation long enough to determine the end-results. All of these obtained bony union. Only two of these showed any late changes in the head.

FRACTURE OF HIP

TABLE I

SYNOPSIS OF 25 FRACTURES OF THE NECK OF THE FEMUR TREATED BY INTERNAL FIXATION

Sex	Age	Date of Operation	Period of Hospitalization	Type of Fracture	Type of Fixation	Time Required for Bony Union	End-Results
1 F	52	1-13-36	13 days	Subcapital	Smith-Petersen nail	Nonunion	Walks with nail giving support. Some shortening and pain.
2 F	78	2-6-36	32 days	Subcervical	Smith-Petersen nail	8 mos	No pain or shortening.
3 F	76	3-4-36	22 days	Subcapital	Smith-Petersen nail	6 mos	Slight shortening and some arthritis. Very little pain.
4 F	82	6-16-36	50 days	Subcapital	Smith-Petersen nail	Died 5 mos later with stroke. Had been walking on crutches. Recent roentgenograms had not been taken to determine amount of union.	Had no symptoms. No pain or shortening.
5 M	81	8-10-36	24 days	Midcervical	Smith-Petersen nail	7 mos	No pain or shortening.
6 F	79	9-29-36	45 days	Subcapital comminuted	Smith-Petersen nail	6 mos	No pain or shortening.
7 M	43	2-4-37	45 days	Subcapital	Smith-Petersen nail	4 mos	No pain or shortening.
8 M	39	2-26-37	60 days	Subcapital	Smith-Petersen nail	Nonunion	Developed aseptic abscess several months after operation. Infection later developed in sinus tract. Colonna operation eventually performed, with good result.
9 F	49	3-23-37	40 days	Subcapital	Smith-Petersen nail	7 mos	No pain or shortening.
10 F	68	5-27-37	54 days	Subcapital	Smith-Petersen nail	14 mos	No pain or shortening.
11 M	80	6-23-37	26 days	Subcapital	Smith-Petersen nail	Died 5 mos later with cardiorenal disease.	Results unknown.
12 M	58	8-27-37	14 days	Inter-trochanteric	Smith-Petersen nail	3 mos	No pain or shortening.
13 F	54	10-20-37	22 days	Subcapital comminuted	Bone graft	6 mos	No shortening.
14 M	74	12-6-37	60 days	Inter-trochanteric	Smith-Petersen nail	3 mos	No pain or shortening.
15 F	72	12-13-37	30 days	Subcapital	Smith-Petersen nail	5 mos	No pain or shortening.
16 F	95	1-12-38	18 days	Trochanteric	Steel nails	4 mos	Slight bowing, very little pain. Died 5 mos after operation with stroke.
17 F	60	1-17-38	20 days	Trochanteric	Moore nails	7 mos	No pain or shortening.
18 M	52	1-24-38	6 days	Trochanteric	Moore nails	6 mos	This fracture was about 3 mos old when seen with no union. Slight shortening. Now solid union.
19 F	75	2-2-38	16 days	Subcapital	Smith-Petersen nail	5 mos	No pain or shortening.
20 F	78	3-7-38	26 days	Midcervical	Smith-Petersen nail	4 mos	No pain or shortening.
21 M	83	4-2-38	12 days	Trochanteric	Moore nails	4 mos	No pain or shortening.
22 M	45	5-28-38	12 days	Trochanteric	Moore nails	3 mos	No pain or shortening.
23 F	60	6-9-38	11 days	Midcervical	Smith-Petersen nail	4 mos	No pain or shortening.
24 F	82	7-5-38	23 days	Subcervical	Smith-Petersen nail	3 mos	No pain or shortening.
25 F	42	9-28-38	16 days	Trochanteric	Moore nails	Patient is walking on crutches. Union is practically complete.	

James Dickson⁷ reports a series of 18 cases. Twelve of these cases had been operated upon long enough to see end-results, all of which obtained bony union. The other six were healing satisfactorily.

Henderson⁸ reports a series of 14 patients with an 86 per cent bony union and no mortalities.

Moore⁹ reports 25 cases of intracapsular fractures in which sufficient time had elapsed to make a definite end-result study. Only one failed to obtain bony union. In other words, there was a 96 per cent successful end-result. There were no deaths attributable to the operation.

R I Harris¹⁰ reports 50 cases of intracapsular fracture of the neck of the femur treated by internal fixation, the Smith-Petersen nail being used in all of the patients. Bony union was obtained in 76 per cent of the cases. Five patients died, giving a mortality of 10 per cent. There was an 80 per cent bony union in the surviving patients.

Plummer¹¹ reported 33 cases of intracapsular fracture. Only two patients died within the ten-day postoperative period. While he does not give a percentage of bony union, one gathers from his report that his experiences have been highly successful.

CONCLUSIONS

(1) A review of the literature reveals that the treatment of fractures of the neck of the femur by closed methods does not give satisfactory results.

(2) The use of internal fixation for fractures of the neck of the femur is a safe procedure. It decreases the financial strain on the patient, lessens the period of hospitalization, lowers the mortality and very definitely improves the end-results.

REFERENCES

- ¹ Campbell, Willis C, Orr, H, Winnett, and Osgood, Robert B. Report of a Commission Appointed by the A. O. A. to Study End-Results of Intracapsular Fracture of the Neck of the Femur. *Jour. Bone and Joint Surg.*, 12, 966-969, 1932.
- ² Cleveland, Mather, and Bosworth, David M. Fractures of the Neck of the Femur. *Surg., Gynec. and Obstet.*, 66, 646-656, March, 1938.
- ³ Watson-Jones, R. Fractures of the Neck of the Femur. *Brit. J. Surg.*, 23, 787-808, April, 1936.
- ⁴ Smith-Petersen. *Arch. Surg.*, 23, 715, 1931.
- ⁵ Leadbetter, G. W. A Treatment for Fracture of the Neck of the Femur. *Jour. Bone and Joint Surg.*, 31, 931-940, October, 1933.
- ⁶ Campbell, Willis C. Internal Fixation in Fractures of the Neck of the Femur. *ANNALS OF SURGERY*, 105, 939-951, June, 1937.
- ⁷ Dickson, James A. The Treatment of Central or Intracapsular Fracture of the Neck of the Femur. *Cleveland Clinic Quarterly*, 5, 41-48, January, 1938.
- ⁸ Henderson, Melvin S. Internal Fixation for Recent Fracture of the Neck of the Femur. *ANNALS OF SURGERY*, 107, 132-142, January, 1938.
- ⁹ Moore, Austin T. Fracture of the Hip Joint, Treatment by Extra-Articular Fixation with Adjustable Nails. *Surg., Gynec. and Obstet.*, 64, No. 2 A, 420-436, February, 1937.
- ¹⁰ Harris, R. I. Experiences with Internal Fixation in Fresh Fractures of the Neck of the Femur. *Jour. Bone and Joint Surg.*, 20, 114-123, January, 1938.
- ¹¹ Plummer, W. W. Comments on Internal Fixation in Fresh Fractures of the Neck of the Femur. *Jour. Bone and Joint Surg.*, 20, 97-107, January, 1938.

BRIEF COMMUNICATIONS AND CASE REPORTS

JACKSON-GALLAGHER DEPTH GAUGE

JAMES A JACKSON, M D

SECTION OF SURGERY, JACKSON CLINIC

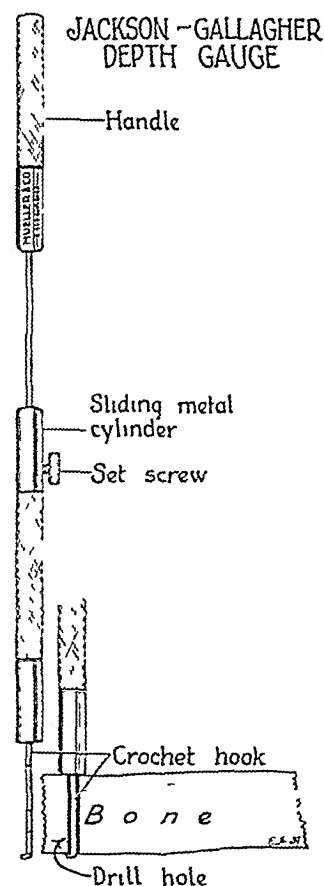
MADISON, WIS

IN the open reduction and plating of fractures of the shaft of a long bone transfixion screws are often required, especially is this true when the shaft of the femur is plated. To obtain the correct length of the screw to be used, *i e*, one that will contact and fix both cortices of the bone, it has been customary to use a micrometer or caliper. The same applies wherever transfixion screws are used in bone work. This is a cumbersome and tedious procedure and due to the variable thicknesses of the bone and the different angles at which the screws are inserted, is not an accurate method.

Surgeons are often surprised to find on examining postoperative roentgenograms that the screws used were frequently either too long or too short. To obviate this difficulty we have devised a simple instrument that we term a depth gauge.

The accompanying illustration is almost self-explanatory. The instrument consists of a shaft of stiff wire with a small crochet hook on the lower end. On the shaft is a sliding metal cylinder with a set screw.

To determine the exact length of the screw to be used, the wire is passed completely through the drilled hole in the bone and then pulled back until the crochet hook lodges against the opposite cortex. The sleeve is now dropped against the bone and the set screw locked. The instrument is then withdrawn and the distance from the end of the sleeve to the crochet hook gives the exact length of screw required for that particular hole. When using a plate one must allow for its thickness. In using self-tapping screws it is well to allow for the tapered end of the screw.



We wish to express our appreciation to Mr. Ted Larson of the V. Mueller Company of Chicago for his cooperation in making this instrument.

Submitted for publication July 26, 1939

WATERMELON SEED IN GALLBLADDER

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THE NUMBER of recorded cases of foreign bodies in the gallbladder is comparatively small Toland,¹ in 1933, reported a case of common duct obstruction which, at operation, revealed a bolus of cotton gauze impregnated with bile, bile salts and fibrin The cotton gauze had been left in the gallbladder at a former operation by a different surgeon Toland reviews the literature and lists the types of foreign bodies that have been reported to have been found in the biliary tract, including such objects as a rifle bullet, seeds, worms, steel needles, piece of wire, swabs, rubber drain tube and handle of a spoon

The case herewith reported is from a cadaver in the Anatomic Laboratory and the foreign body was discovered by two medical students, J S Arnold and J H McVicker The department records on this cadaver are very meager The body was sent to the Anatomic Board from a private mortuary and it has not been possible to obtain any information regarding either the medical diagnosis or treatment before death The death certificate gives the following information

Case Report—Negro, female, age 65 Died August 28, 1936 *Cause of Death* "Chronic myocarditis, senility"

Autopsy Findings—Dissection of body was begun, September 26, 1938 The cadaver was exceedingly obese The skin was intact on all parts of the body with the exception of the thigh where incision had been made for embalming There was no scar indicating any surgical procedure during life On opening the gallbladder, a well preserved watermelon seed was found in it together with some five or six gallstones of various sizes There were no adhesions of the gallbladder to any part of the stomach or intestines, indicating any possible previous ulcer The common bile duct measured 12 Mm in diameter in the flattened state The ampulla of Vater was very prominent It extended into the cavity of the duodenum as a conical papilla of about 10 to 12 Mm in height (it was not measured) Two prominent folds of mucous membrane extended from the summit of the ampulla distally The gallstones were examined chemically by Mr McVicker and were found to consist of cholesterol and ergosterol

Discussion—The significance of the possibility of foreign bodies migrating from the duodenum to the gallbladder, in the etiology of gallbladder disease, is immediately apparent It has generally been held that foreign bodies do not pass from the duodenum to the gallbladder Toland says "It is logical to assume needles and other sharp objects that have been swallowed and reached the pylorus might migrate by direct contiguity into the gallbladder The curious circumstances that lead to such migration are difficult to visualize Inanimate foreign bodies in the gallbladder can hardly be explained on the basis of retrograde migration from the duodenum through the ampulla of

Vater, but the motile round worm could easily reach the gallbladder by this route "

The importance of ascending biliary infection in the etiology of gallbladder infection has been recognized in standard text-books Babcock,² in his Text-Book of Surgery, says "The bacteria enter the ampulla of Vater, passing through the common and cystic ducts into the gallbladder This process may be aided by the reverse currents described by Bond, who found that caimin introduced into the rectum would ascend and pass out through a gallbladder fistula "

The actual passage of duodenal contents into the biliary system has been recorded by a number of authors Such a reflux of duodenal contents, apparently, was first noted, clinically, by Codman,³ in 1908 McArthur,⁴ in 1923, reported a case of reflux of barium into the common bile duct Davis,⁵ in 1929, reported four cases of duodenal reflux Walters and Marshall,⁶ in 1930, reported four cases in which pancreatic enzymes were recovered from drainage tubes in the biliary system They also found that methylene blue given by mouth appeared in the drainage material Bernard,⁷ in 1934, reported eight cases of duodenal reflux This occurred in patients after choledochoduodenostomy, choledochotomy and cholecystectomy The reflux was demonstrated roentgenologically after a barium meal In some cases the barium extended into the smaller radicals of the hepatic ducts

Reflux of duodenal contents has also been demonstrated by animal experimentation Higgins and Mann,⁸ in 1926, working on the bile expulsion mechanism in guinea-pigs, reported that portions of test meals injected into the duodenum pass directly into the common bile duct The following year, Burget and Brocklehurst⁹ were not able to force duodenal contents into the intact ampulla of the guinea-pig These authors reinvestigated the anatomy of the biliary tract in the guinea-pig and describe a "contractile ampulla which opens into the duodenum" This structure is apparently peculiar to the guinea-pig

More recently, Auer and Seager¹⁰ have investigated the problem of reflux of duodenal contents into the biliary system of the guinea-pig In 23 out of 26 guinea-pigs, they were successful in forcing an oil dilute India ink into the gallbladder and biliary passages The effective duodenal pressures necessary for duodenal reflux ranged between 10 and 20 Mm Hg

Another type of reflux into the biliary system has been investigated, especially by Wolfe^{11, 12} In 1931, he reported on the results of experiments of introducing pancreatic juice into the gallbladder of dogs In 1937, he reported a case of pancreatic juice reflux into the gallbladder of a patient and reviewed the literature on this type of reflux into the biliary system As stated by Wolfe, this type of reflux is perhaps dependent upon total or partial obstruction of the ampulla of Vater and especially in such cases where the pancreatic duct and the common bile duct join to have a common opening into the duodenum

A few references in the literature to "duodenal reflux" deal with duodenal regurgitation into the stomach. It is suggested that the term "duodenal reflux" be limited to a passage of duodenal contents into the biliary system.

There seems to be no other explanation for the presence of the watermelon seed in the gallbladder than that it passed by way of the ampulla of Vater and the common duct. From the appearance of the seed, together with the season and the observation of a great quantity of seeds in the large intestine, its sojourn in the gallbladder had probably been of only a few days' duration before death.

In the list of foreign bodies given by Toland, the majority of the foreign bodies represent accidental inclusions resulting from surgical procedures. Meitens¹³ (1898) reported two instances of worms (*Ascaris lumbricoides*) which had undoubtedly entered by way of the ampulla of Vater. Although various authors mention cherry stones and seeds as having been found in the gallbladder, I have been unable to locate the original reports of any such observations. Mertens and Deaver,¹⁴ referred to by Toland, make no mention of seeds in the gallbladder.

The presence of seeds in the gallbladder could hardly be accounted for by any other route than the ampulla of Vater and the common duct, unless, as has been suggested, by a rupture of an ulcer of the stomach which was adherent to the gallbladder. As stated above, there was no evidence of any such pathology in the case here reported.

REFERENCES

- ¹ Toland, C. G. Foreign Bodies in the Biliary Tract. *ANNALS OF SURGERY*, 98, 904, 1933.
- ² Babcock, W. W. A Text-Book of Surgery. W. B. Saunders Co., Philadelphia, 1135, 1929.
- ³ Codman, E. A. Observations of Six Cases of Acute Perforating Ulcer of the Duodenum. *Boston Med and Surg Jour*, 158, 217, 1908.
- ⁴ McArthur, L. L. Repair of the Common Bile Duct. *ANNALS OF SURGERY*, 78, 1929, 1923.
- ⁵ Davis, Lincoln. Reflux of Duodenal Contents Through the Common Bile Duct. *New England Jour Med*, 200, No 7, 313, 1929.
- ⁶ Walters, W., and Marshall, J. M. Reflux of Pancreatic and Duodenal Secretions Through Drainage Tube in Common Bile Duct. *Surg, Gynec and Obstet*, 50, 627, 1930.
- ⁷ Bernhard, Fr. Welche Bedeutung ist dem Einringen von Magendarminhalt in die Gallenwege nach Anastomosen und insbesondere nach der Choledochoduodenostomie beizumessen? *Arch f klin Chir*, 180, 543, 1934.
- ⁸ Higgins, George M., and Mann, Frank C. Observations on the Emptying of the Gallbladder. *Amer Jour Physiol*, 78, 339, 1926.
- ⁹ Burget, G. E., and Brocklehurst, R. J. The Bile-Expelling Mechanism of the Guinea-Pig. *Amer Jour Physiol*, 83, 578, 1927-1928.
- ¹⁰ Auer, J., and Seager, L. D. Entry of Duodenal Contents into the Biliary System of the Guinea-Pig. *Soc Exper Biol and Med*, 37, 281, 1937-1938.
- ¹¹ Wolfer, J. A. Pancreatic Juice as a Factor in the Etiology of Gallbladder Disease. *Surgery*, 1, 928, 1937.

- ¹² Wolfer J A The Role of Pancreatic Juice in the Production of Gallbladder Disease
Surg, Gynec and Obstet, 53, No 4, 433, 1931
- ¹³ Mertens Zwei Falle von Einwanderung von Spulwürmern in das Gallengangssystem
Deutsch med Wchnschr, 24, 358, 1898
- ¹⁴ Deaver, J B Vermont Med Monthly, 20, 92, 1914

TUBERCULOSIS OF THE LATERAL LUMBAR VERTEBRAL MASS

OPERATIVE CURE

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TUBERCULOUS OSTEOMYELITIS of the lateral lumbar vertebral mass of any of the vertebra without simultaneous involvement of the corresponding body has, as far as we can ascertain, not yet been reported in the literature

The following case was encountered while the patient was under treatment for tuberculous osteomyelitis of the thoracic wall and for tuberculous lymphadenitis of the cervical region (postoperative) We believe this case is one of unusual interest in that the site of the spinal infection is a rare one, and also that the lateral portions of the ribs are not frequently the source of abscess of the chest wall (Alexander¹, and Carr and Alexander²)

Case Report—C D, Filipino, male, age 34, was admitted to the New Jersey Sanatorium, Glen Gardner, N J, July 20, 1936, with a diagnosis of minimal pulmonary tuberculosis The lesion was discovered during a routine examination of food handlers He had had a right cervical adenectomy performed in August, 1935, for ulcerative adenitis The wound had failed to heal completely He was asymptomatic except for a 24-pound weight-loss since November, 1935 (eight months) Incidentally, he gave no history relative to the draining sinuses located in the axillary region over approximately the eighth rib, which were discovered during physical examination Inquiry, however, showed that the onset had been gradual, commencing about November, 1935

Physical Examination—The patient appeared chronically ill, and decidedly underweight There was a series of draining sinuses extending from about 4 cm below the mastoid process on the right to approximately 6 cm above the clavicle, and 2 cm posteriorly from the lateral border of the sternocleidomastoid muscle These had the appearance of tuberculous sinuses There was also a cluster, one large and several small, of sinuses located over the seventh and eighth intercostal spaces and the eighth rib in the axillary region on the right side The surrounding area was raised, but no tenderness could be elicited Cheesy material was expressed in considerable quantities upon moderate pressure The impression was gained that more than one rib was involved The regional lymph nodes were considerably enlarged but not tender The examination of heart, lungs, abdomen, etc, was negative

Laboratory Data—Sputum and urine were negative for acid-fast bacilli Blood and urine were normal Roentgenologic examination of the chest showed an old fibrous, minimal lesion in the apex of the left lung as well as destruction of the eighth rib in the axillary line with an accompanying soft tissue swelling and a localized area of density

Submitted for publication September 30, 1938

resembling fluid, protruding into the pleural space immediately subjacent to the involved rib

The patient was first placed upon routine sanatorium regimen for a period of about two weeks. He was then referred to the Surgical Service. The complete operation was divided into two stages because the process was far more extensive than appeared upon first examination. Careful probing of the sinuses revealed ribs 6, 7, 8, and 9 to be involved.

Operation—August 5, 1936. The principles employed in resecting the involved tissue and bone followed those described by Alexander, namely "Radical excision of every bit of infected tissue and of any normal cartilage that has been cut into." The final closure was not complete, necessitating the leaving of an area which granulated in and was ultimately closed by skin graft. The subsequent postoperative course was essentially uneventful, even though the process had eroded through the parietal pleura, causing a local accumulation of fluid. Postoperative aspirations were necessary but empyema did not develop.

Subsequent Course—An uneventful convalescence, with satisfactory clinical improvement and weight-gain, marked the patient's course until October 21, 1936, when a mass, approximately the size of an orange, suddenly appeared over the right iliac region. On examination, this mass proved to be definitely fluctuant and without associated pain, tenderness, or increase in local heat. Aspiration was performed and a quantity of thick pus obtained. Bacteriologic study of the specimen was reported as negative for all organisms.

Intravenous pyelograms and anteroposterior and lateral roentgenographic projections of the spine were made. The former showed no evidence of a destructive lesion of either kidney. The latter, however, revealed a destructive process involving the lateral third lumbar vertebral mass (Figs 1 and 2). The process was one of bone destruction, practically without bone formation, and therefore, was concluded to be tuberculous osteomyelitis. It was also observed that, in the anteroposterior projection, there was an obliteration of the lateral border of the silhouette of the psoas muscle, while on the contralateral side there was no such interference with the normal psoas shadow. Because of the age of the patient (approximately 34 years at the time of onset), and the fact that, at operation, a fair-sized sequestrum was removed, we are inclined to believe this process was of comparatively recent origin and did not date back to the time of adolescence before body growth was complete.

We mention this specifically, because the lateral projection shows that the destructive process has involved the side of the body of the vertebra as well as the transverse process. In this view, one may also note a decrease in the density of the pedicle. Embryologically, then, the total area involved corresponds to the lateral mass of the vertebra except its posterior portion, and, therefore, we were dealing with a tuberculous osteomyelitis of the lateral mass of the third lumbar vertebra and not merely of the transverse process itself. The negative bacteriologic reports on pus obtained from the cold abscess, and the presence of preexisting tuberculous lesions elsewhere, were taken as presumptive evidence substantiating our diagnosis. Pus accumulated quite rapidly in the abscess pocket and eventually broke through a needle track which had failed to heal even though it was not dependently placed and had passed through healthy tissue before entering the abscess cavity.

It was not felt that we were dealing with a true Pott's disease, but rather with a condition quite comparable to a tuberculous osteomyelitis of the rib. In view of this, open operation was decided upon.

Second Operation—November 18, 1936. Under a 5 per cent procaine local anesthesia, an 8 to 9 cm longitudinal incision was made centering over the involved transverse process and placed between the junction of the outer one-third and inner two-thirds of the erector spinae muscles. Blunt dissection was used as far as possible throughout the procedure. This brought a large abscess directly into the operative field, and about four to five ounces of thick pus was evacuated. A sequestrum, the size of an olive, was found



Fig. 1—Anteroposterior projection. Note the destructive process involving the transverse process and portion of the lateral mass of the third lumbar vertebra.

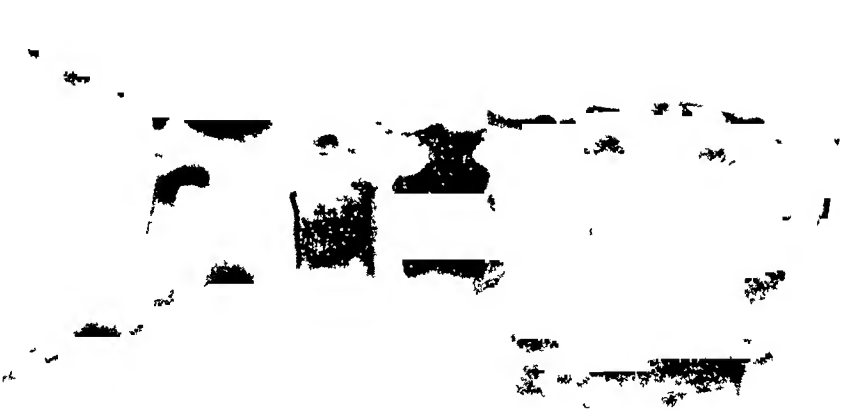


Fig. 2—Lateral projection. Note the area of bony destruction of the body of the third lumbar vertebra.

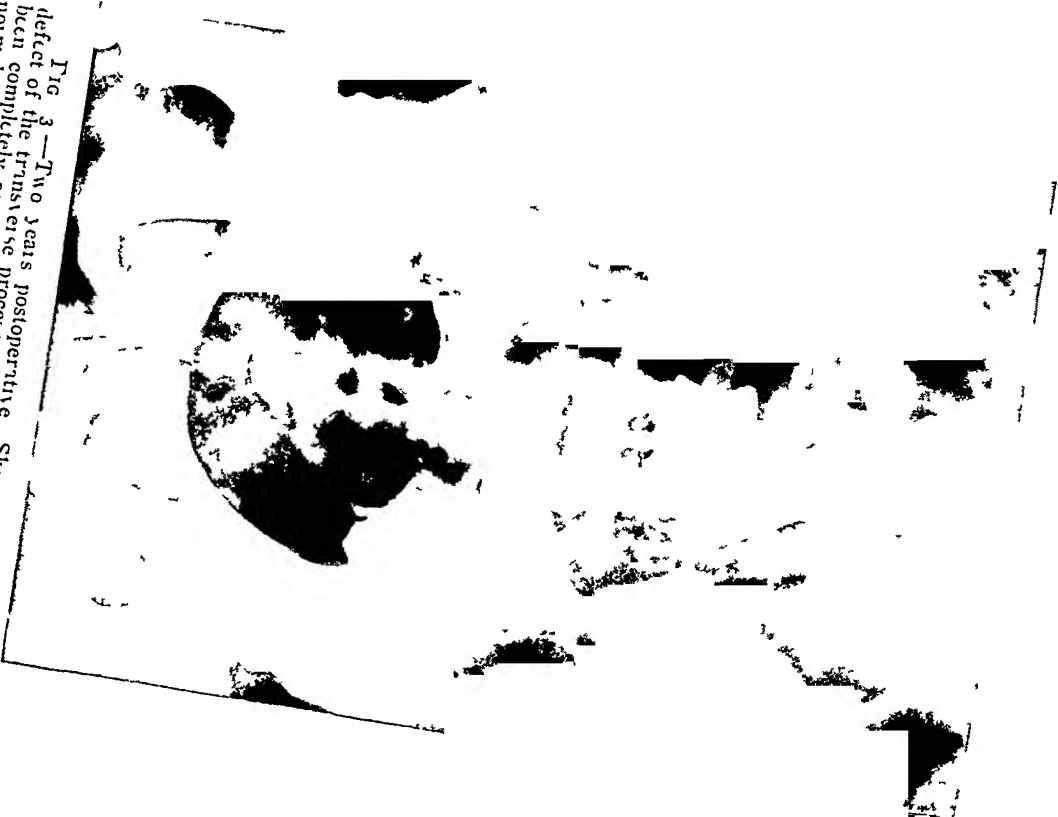


Fig. 3—Two years postoperative. Showing a residual defect of the transverse process. The destructive lesion has been completely excised and the bony outline returned to normal.

lying free in the place occupied by the transverse process. This was removed and, subsequently, examined microscopically. The medial wall, formed by the vertebra proper, was thoroughly curetted. The remaining tip of the process and spinal nerves were involved in dense scar tissue. The total removal of the tip seemed impractical because of possible injury to the spinal nerves. This area was, therefore, also curetted as were the remaining walls of the cavity. Following this, an adequate pedicle muscle transplant was developed from the adjacent muscle mass. The free end was firmly fastened in the cavity so that it completely filled the space. The wound was then closed with No. 1 chromic catgut. Black silk was employed to close the skin. The sutures were removed in seven days.

Material removed at the time of operation, including the sequestrum, showed early tubercle formation on pathologic examination. We believe that this adequately substantiates the preoperative clinical and roentgenologic diagnosis.

Subsequent Course—Convalescence was quite uneventful. No further drainage occurred, and all wounds healed satisfactorily. After an adequate period of bed rest he was started on progressive exercise and finally discharged, September 10, 1937. All wounds, including the cervical sinuses, had been healed for a long time when he left the sanatorium. Since discharge, he has returned to his occupation as a cook. Frequent check-up examinations, including roentgenologic examination (Fig. 3), have all been thoroughly satisfactory. His total weight-gain has been approximately 35 pounds to date.

At the present time the patient is the only living member of a group of four living together prior to his admission. All others have since died of tuberculosis.

COMMENT—No similar case has been found by us in the literature and, therefore, we assume that we are not only reporting a case of an unusual site for metastatic tuberculous infection, but also have employed a procedure which has given highly satisfactory results which would justify further use with but one modification. We believe that the tip of the transverse process should be completely removed if possible. We thoroughly realize, however, that no definite conclusion can be reached on the basis of a single case.

REFERENCES

- ¹ Alexander, John. *The Collapse Therapy of Pulmonary Tuberculosis*. Springfield, Ill., and Baltimore, Md., Charles C. Thomas, Chap. XXXI, 1937.
- ² Carr, Duane, and Alexander, J. Tuberculosis of the Thoracic Wall. *Jour. Thoracic Surg.*, 3, 380, 1934.

BOOKS RECEIVED

THE receipt of books for review is hereby acknowledged. This statement shall be regarded as sufficient acknowledgment of the courtesy of the publishers. Selections will be made for review predicated upon the interests of the readers of the ANNALS OF SURGERY and as space permits.

TEXTBOOK OF GENERAL SURGERY By Warren H. Cole, M.D., and Robert Elman, M.D. Second Ed. New York: D. Appleton-Century Co., Inc., 1939.

PRATICA CHIRURGICA By Vittorio Puccinelli, M.D. Bologna, Italy: L. Cappelli, 1939.

MANUAL OF REPARATIVE SURGERY By J. Eastman Sheehan, M.D. New York: Paul B. Hoeber, Inc., 1939.

FROM HEAD TO FOOT By Armitage Whitman, M.D. New York: Farrar and Rinehart, Inc., 1939.

THE STORY OF SURGERY By Harvey Graham. New York: Doubleday, Doran & Co., Inc., 1939.

THE 1938 YEAR BOOK OF UROLOGY, Edited by John H. Cunningham, M.D. GENERAL THERAPEUTICS, Edited by Bernard Fantus, M.S., M.D., and Aaron L. Goldberg, M.D. NEUROLOGY, PSYCHIATRY AND ENDOCRINOLOGY, Edited by Hans H. Reese, M.D., Harry A. Paskind, M.D., Ph.D., and Elmer L. Sevringhaus, M.D. PEDIATRICS, Edited by Isaac A. Abt, D.Sc., M.D., and Arthur F. Abt, M.D. PHYSICAL THERAPY, Edited by Richard Kovacs, M.D. DERMATOLOGY AND SYPHILOLOGY, Edited by Fred Wise, M.D., and Marion B. Sulzberger, M.D. OBSTETRICS AND GYNECOLOGY, Edited by Joseph B. DeLee, M.D., and J. P. Greenhill, M.D. Chicago: The Year Book Publishers, 1938.

THE 1939 YEAR BOOK OF RADIOLOGY Edited by Charles A. Waters, M.D., Whitmer B. Firor, M.D., and Ira I. Kaplan, B.Sc., M.D. Chicago: The Year Book Publishers, 1939.

OFFICE GYNECOLOGY By J. P. Greenhill, M.D. Chicago: The Year Book Publishers, 1939.

LA FOTOGRAFIA DEL ESTOMAGO By Jose P. Vslenghi, Joseph Hofmann, and Joseph Heilpern. Buenos Aires: Aniceto Lopes—imp—1939.

Transactions of the Southern Surgical Association Vol. LI Edited by Alton Ochsner, M.D. Philadelphia: J. B. Lippincott Co., 1939.

TUMORS OF THE SKIN By Joseph J. Eller, M.D. Philadelphia: Lea & Febiger, 1939.

TUMORS OF THE HANDS AND FEET By George T. Pack, M.D. St. Louis: C. V. Mosby Co., 1939.

HOSPITAL FOR THE RUPTURED AND CRIPPLED: AN HISTORICAL SKETCH By Fenwick Beekan, M.D. Privately printed, 1939.

PATOLOGIA Y CIRUGIA DEL ESFINTER DE ODDI By Delfor del Valle (H). Libreria Y Editorial "EL ATENEIO". Buenos Aires, 1939.

THE SURGERY OF INJURY AND PLASTIC REPAIR By Samuel Fomon, Ph.D., M.D. A William Wood book. Baltimore: Williams & Wilkins Co., 1939.

YEAR BOOK OF GENERAL SURGERY Edited by Evarts A. Graham, M.D. GENERAL MEDICINE Edited by Doctors Dick, Amberson, Jr., Minot, Castle, Stroud and Eusterman. EYE, EAR, NOSE AND THROAT Edited by Doctors Brown, Bothman, Crose, Hagens and Green. Chicago: The Year Book Publishers, 1939.

CONTROL OF FEDERAL EXPENDITURES: A DOCUMENTARY HISTORY Compiled by Fred W. Powell. Washington: The Brookings Institution, 1939.

BOOK REVIEW

SURGICAL TREATMENT OF HAND AND FOREARM INFECTION By Dr A C J BRICKEL, A B, M D Dept of Anatomy and Surgery, Western Reserve University 291 pages 166 text illustrations, 35 plates, including 10 in colors, C V Mosby Co, St Louis, 1939

For those who are interested in hand infections, here is a comprehensive treatise written by Dr A C J Brickel. The volume is a thought-producing book divided into seven chapters, so grouped that the busy practitioner can easily find the part dealing with one of his particular cases. The monograph has beautifully colored plates and illustrations which deal with the clinical as well as the surgical anatomy of the hand and forearm. The clinical notes following each description of the compartments of the hand impress one with the importance of properly placed incisions in the hand. The author carefully points out important structures to be avoided, thus reducing the impairment of the function of the hand. The value of the various incisions in the treatment of the individual types of infections is clearly shown by the illustrations.

Following each chapter, the general comments and conclusions will be found to be of aid to the industrial and general surgeon, who is in haste to obtain concrete knowledge concerning an accurate diagnosis of various types of infections, within a short space of time. Other chapters deal with anesthesia, physiotherapy, and medicolegal considerations.

We know that through the use of the hand and arm, man is able to exploit his brain to the fullest extent. The hand is man's second brain, for with it he builds homes, assembles automobiles, builds aeroplanes, writes books, *etc*. The hand is also a supplementary eye, in that, in total darkness, it guides him and gives a sense of security. When one muses and meditates over the dire end-results of hand infections, then it becomes apparent what a useful hand means to a working man.

As an antidote for better results in hand infections, I strongly recommend a careful perusal of this book.

JEROME J. WEINER

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Original typed manuscripts and illustrations submitted to this Journal should be forwarded prepaid, at the author's risk, to the Chairman of the Editorial Board of the ANNALS OF SURGERY

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1833 Pine Street, Philadelphia, Pa

Contributions in a foreign language when accepted will be translated and published in English.

Exchanges and Books for Review should be sent to James T. Pilcher, M D, Managing Editor, 121 Gates Avenue, Brooklyn, N Y.

Subscriptions, advertising and all business communications should be addressed

ANNALS OF SURGERY
227 South Sixth Street, Philadelphia, Pa

ANNALS OF SURGERY

VOL 111

MARCH, 1940

No 3



SYMPOSIUM ON CHRONIC PEPTIC ULCER

PRESENTED BEFORE

The New York Surgical Society
New York, N Y, April 12, 1939

THE RÔLE OF SURGERY IN THE MANAGEMENT OF DUODENAL ULCER

JOHN J WESTERMANN, JR, M D, New York, N Y

CHRONIC DUODENAL ULCER

J WILLIAM HINTON, M D, and ROLAND L MAIER, M D, New York, N Y

PROBLEMS IN THE SURGICAL TREATMENT OF CHRONIC DUODENAL ULCER

RICHARD LEWISOHN, M D, New York, N Y

DISCUSSIONS BY

MORRIS K SMITH, M D

JOHN A McCREERY, M D

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HUBLEY R OWEN, M D

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THE RÔLE OF SURGERY IN THE MANAGEMENT OF DUODENAL ULCER*

JOHN J WESTERMANN, JR, M D
NEW YORK, N Y

A SURGICAL procedure, for any given pathologic condition, must fulfill the following requirements if it is to be successful. Satisfactory immediate recovery, brief and uncomplicated convalescence, early return to usefulness, and permanency of cure¹

I have made a study of 64 consecutive cases of chronic duodenal ulcer treated by posterior gastro-enterostomy, to determine to what degree this procedure has fulfilled these requirements

I appreciate fully that the majority of surgeons, at the present time, are opposed to posterior gastro-enterostomy in the treatment of chronic duodenal ulcer. This opposition is based almost entirely upon the fact that this procedure is followed so frequently by jejunal ulcer. However, in a review of many of the reports in favor of gastric resection, one finds no distinction made between partial gastric resection and subtotal gastric resection. That partial resection is frequently followed by jejunal ulcer is well recognized,² and subtotal resection is not immune to this complication.

Subtotal gastrectomy, specifically, the removal of all but the fundus of the stomach, with fundojejunal anastomosis, is a satisfactory operation and fulfills our last requirement. It does not demand the minute detail of a perfect gastro-enterostomy to assure satisfactory function. Immediate mortality and postoperative complications will, of necessity, never be eliminated. In these reports there has been a striking improvement in mortality, but these have come from the large surgical clinics, where the appointments from anesthesia to the utmost in postoperative care are immediately available as routine measures.

However, I cannot agree that it is justifiable, in surgical teaching, to recommend subtotal gastrectomy as the only surgical procedure for the cure of chronic duodenal ulcer. It will follow that, in the hands of those of lesser experience, less stomach will be resected. Mortality and immediate complications will be high. Partial and low resections do not insure permanency of cure.

Marshall and Kiefer³ state that unless anacidity or hypo-acidity is produced by high resection it is difficult to see any clinical advantage of this operation over gastro-enterostomy.

Habeier's⁴ enviable series of 100 consecutive gastric resections without any mortality were according to the Billroth I method. In my own experi-

* Read before the New York Surgical Society, April 12, 1939. Submitted for publication March 17, 1939.

ence, this procedure has not exhibited permanency of cure in the treatment of duodenal or gastric lesions

Lahey and Marshall⁵ state that the Billroth I operation is the safest of all types of gastric resection. They prefer Hofmeister's method for radical resection. Their mortality in 130 cases is 18 per cent, the incidence of jejunal ulcer, 7 per cent.

Lewisohn⁶ reported a record breaking incidence of jejunal ulcer and now says "If gastric resection is to replace gastro-enterostomy in the surgical treatment of duodenal ulcer it must answer two requirements. Mortality must not be higher and incidence of recurrent ulcer must be much lower." I presume that he refers to jejunal ulcer. He also states that pylorectomies

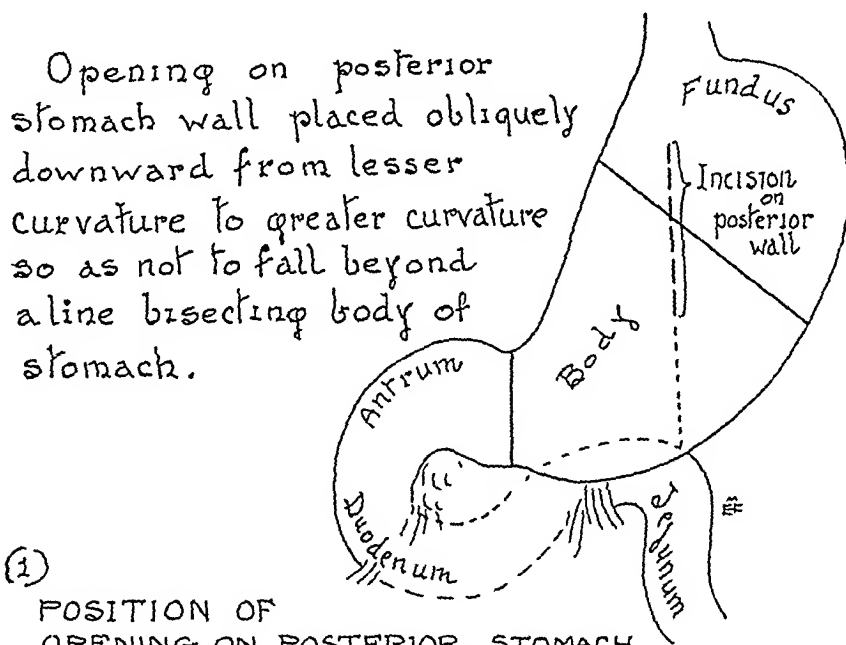


FIG 1

or partial antrumectomies should not be called gastric resections and that these operations are attended by as high mortalities as gastric resection, and will be followed by high incidence of jejunal ulcer.

Cutler⁷ is far less radical in his statements regarding resection, and the future will tell whether his end-results will justify his changing regimen.

And thus we find that a review of statistics shows a general agreement that subtotal resection involves a serious risk and is followed, occasionally, by jejunal ulcer. It is worthy of note that many of the present advocates of gastric resection have reported unduly high mortalities, complications, and jejunal ulcers following posterior gastro-enterostomy.

I would limit the application of posterior gastro-enterostomy to chronic ulcer of the duodenum without hemorrhage, in which satisfactory nonoperative treatment has failed. It has no value in the bleeding type of ulcer. I am also opposed to the "resection for occlusion" procedure for bleeding ulcer. In my own experience, it has been satisfactory in the prevention of further hemorrhage, but has been followed by a high incidence of jejunal ulcer.

Here, subtotal resection offers the only chance for a permanent cure. I believe that posterior gastro-enterostomy has no place in the treatment of gastric lesions, and that anterior gastro-enterostomy should never be employed in any case.

Posterior gastro-enterostomy is not a haphazard fistula between some part of the posterior gastric wall and the jejunum, but a definite, well-planned and carefully placed opening between a certain limited area of the stomach wall and a corresponding segment of jejunum. The stoma must be of sufficient size.

I wish to illustrate a few of the more important steps in the procedure, as I have employed it, and give my reasons for so doing. There is nothing original in these features and I recall them to you simply to emphasize them.

(1) The stomach site falls along a line from lesser to greater curvature, obliquely downward from left to right.

(2) The lower angle of the stoma falls above a line bisecting the body of the stomach.

(3) Serosa of jejunum is buttressed to serosa of stomach for one inch above the upper angle of the stoma.

(4) The opening in lesser sac is affixed to stomach wall about the stoma.

(5) Jejunal site is arbitrarily taken to allow jejunum to fall naturally without angulation when stomach is replaced.

(6) The size of the opening will vary with the size of the stomach, but should not be less than one and one-half inches in diameter.

I use no clamps and no nonabsorbable sutures. I tie all bleeding points both in stomach and jejunal walls. I use two sutures—one continuous for serosa, and one of a self-inverting type for mucosa.

The dictum that the stoma should lie near the pylorus is not based upon sound physiologic reasoning, in my opinion. In the majority of descriptions, [Cannon and Blake,⁸ and others,] where the stoma site is emphasized, this has been the situation of choice. It has been assumed that gravity assisted in the emptying of the stomach and that a low point was necessary for drainage. That this is erroneous is evident, if one considers the stomach of the quadruped. It has also been suggested that a stoma too far to the left predisposes to jejunal ulcer. As far as I can learn this is entirely an empiric idea.

It has been shown⁹ that contact alone does not produce a flow of gastric juice, but that there must be an accompanying stretching of the stomach wall, *i.e.*, a contact plus distention stimulus.

It is reasonable to assume that this stimulus occurs synchronously with, and is identical with that which stimulates peristalsis. The peristaltic waves take origin at the midportion of the body of the stomach. That portion above this point of origin, namely, the proximal one-half the body and the fundus, is free from peristaltic waves, but is the seat of a tonic contraction which steadily continues as gastric digestion proceeds.¹⁰ Thus, a high stoma will at once relieve this pressure and reduce the quality of the stimuli to produce the flow of gastric juice and peristaltic waves. It will also allow the passage

of food to the jejunum before it has become mixed with any appreciable amount of gastric juice. By this means we approximate a stomach at rest—of the greatest significance in the healing and prevention of ulcer formation. As I will show later, there has been no difference in the results in cases where the ulcer was excised and where it was not.

Furthermore, we have retained normal physiologic stimulation of the duodenal mucosa (abandoned in resection) which, in the light of proven experiment,¹¹ is so necessary to the maintenance of proper pancreatic and jejunal digestion. Cowgill¹⁰ states that it is reasonable to believe that the two types of gland control, nervous and hormonal, operate together to secure a balanced control which is capable of some normal degree of variation to meet special situations, and that it is possible for one or the other of the extreme conditions, represented by failure of either control mechanism to operate in appreciable degree, to occur either as the cause or result of disease. As an illustration of this last point, we may cite the observation of Ivy, *et al.*,¹² that pancreatic dysfunction (failure to provide proper alkali?) may be associated with hypersecretion of gastric juice.

The pains of peptic ulcer have been shown¹³ to be due to contractions of stomach and duodenum and not to corrosion and irritation of exposed nerve endings. Thus by reducing the motility and contraction by early emptying, the high stoma also relieves pain. I have found it is satisfactory in those cases presenting intractable pain without pylorospasm.

Stomata placed in the antral portion of the stomach are surrounded by thicker and more powerful muscular coats than in the body of the stomach. This muscle is hypertrophic in the presence of pyloric resistance. A wound through such a wall is productive of a hypertrophic scar—making for a rigid stoma. These factors also operate in encroaching upon the lumen of the stoma. Ryan¹⁴ has observed that the nearer a stoma approaches the pylorus the greater its tendency to close. These factors, I believe, explain his observation.

Schindler¹⁵ has observed that posterior gastro-enterostomies carried out near the pylorus acquire a pyloric-like rhythmic activity which is not timed in the same rhythm as is shown by the pylorus. This rhythmic closure is the result of peristaltic waves as they pass the area of the stoma. Closure occurs during the systolic phase, thus maintaining gastric distention, increasing the stimulus for gastric secretion and insuring a thorough mixing of the meal with gastric juice. Thus, food passing to the jejunum from such a stoma exposes jejunal mucosa to the effects of a food mass which has not been affected by its passage through the duodenum. It seems logical, under such conditions, to expect the production of a jejunal ulcer.

Experimentally ulcers appear with great regularity when small intestine is exposed to acid discharge from the stomach.¹⁶

Theoretically, the following etiologic factors have been presented for the occurrence of jejunal ulcer:

(1) Technical errors—most commonly nonabsorbable sutures found at the

ulcer site This has been a frequent operative observation, and lately has been observed through the gastroscope¹⁵ This type of ulcer is not peculiar to gastro-enterostomy

(2) Use of clamps

(3) Stoma with improper function I believe this to be the most frequent cause It has been my observation that any mechanical factor which results in a maladjustment of the relationship between stomach and intestine, and so effects the proper functioning of the stoma, will predispose to jejunal



FIG 2—Showing the result following a high gastro-enterostomy, 10 years postoperative, no symptoms Note ample emptying after taking barium, no gastric distention, faint staining in the antrum, and no passage of barium via pylorus



FIG 3—Showing the result following a gastro-enterostomy near the pylorus marginal ulcer 14 months postoperative Note the gastric distention, and the larger proportion of the meal passing via duodenum

ulcer This is illustrated in a case in which gastro-enterostomy, performed elsewhere, was followed by incisional hernia Jejunal ulcer promptly followed It is further illustrated in the frequency with which jejunal ulcer occurred when gastro-enterostomy was performed for gastrioptosis, a procedure long since abandoned

(4) It is my conviction that when the stoma is placed near the pylorus we have another cause for jejunal ulcer

In a group of eight marginal ulcers admitted to St Luke's Hospital during the past five years, occurring after both gastro-enterostomy and low resection, the acidity findings were uniformly low The reasons for the jejunal ulcers seem to be apparent Two occurred after low resection, one occurred in a patient with a multiplicity of constitutional diseases Gastric surgery, except of an emergency character, should not be undertaken in the

presence of general constitutional disease, and will quite frequently result in failure. One followed an incisional hernia, one followed gastro-enterostomy of the Roux type, and three followed gastro-enterostomy near the pylorus, showing tendency toward closure in the roentgenologic studies.

I have made the following observations on a group of 64 consecutive cases of chronic duodenal ulcer upon whom I carried out posterior gastro-enterostomy in the manner which has been described.

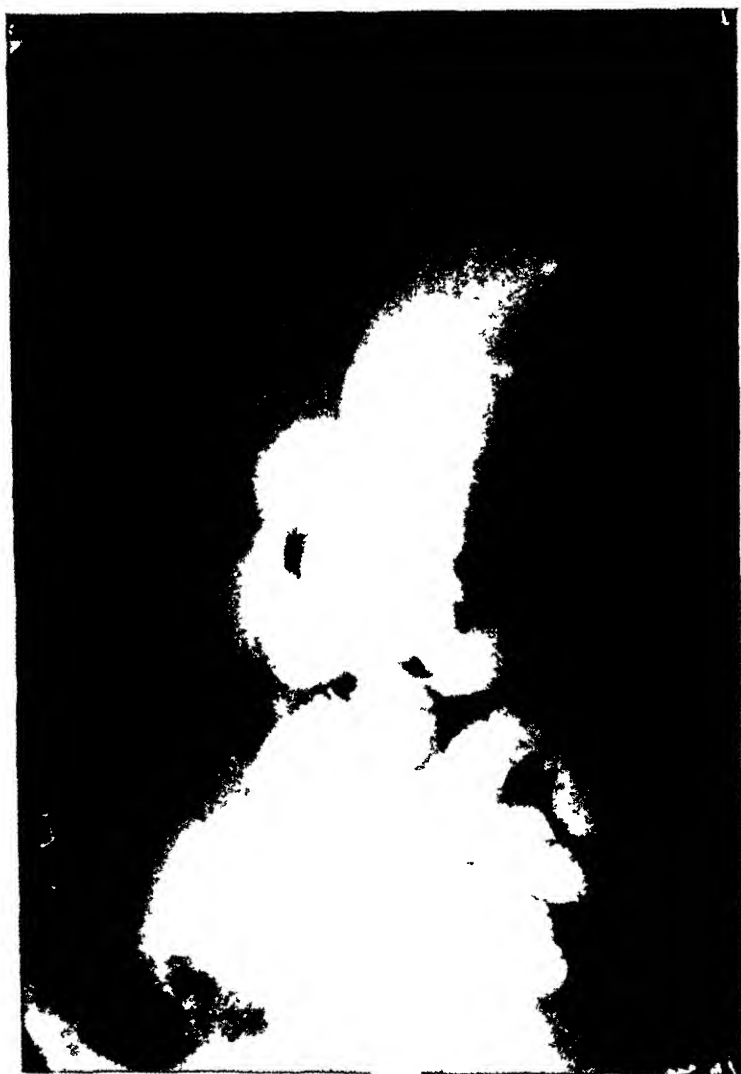


FIG 4—Showing a jejunal ulcer, eight months after a posterior gastro enterostomy, followed by an incisional hernia. Note the distortion of the stomach and its dilatation. Passage of barium, in about equal amounts, via pylorus and stoma, five minutes after ingestion.

There were two postoperative deaths, or 3.12 per cent, one followed wound disruption and a pulmonary complication following resuture of the wound. I have since used silk for wound closure. [I regret to say that I have had, in the past month, a wound disruption, using interrupted silk sutures. The culture showed *Staphylococcus aureus*.] The second was due to obstruction in the distal jejunal loop. A previous peritonitis after appendicitis had caused adhesions between the jejunum and the fossa of Treitz. I made the error of freeing a loop of jejunum with which to make the anas-

tomosis Dense adhesions reformed, causing the obstruction I have found this condition in one patient since then in whom I performed a gastric resection

There were five cases in which the results have been unsatisfactory, 7.6 per cent One case developed jejunal ulcer to my knowledge, and was proved at autopsy I now believe that surgery should not have been undertaken in his case as he was suffering, among other things, with chronic endocarditis

Fifty-four cases have been followed intimately and continuously since operation



FIG 5—A Showing the result two years after gastroentero anastomoses of end to side type, possibly a modified Roux operation Note the jejunal ulcer, one inch below the distal stoma

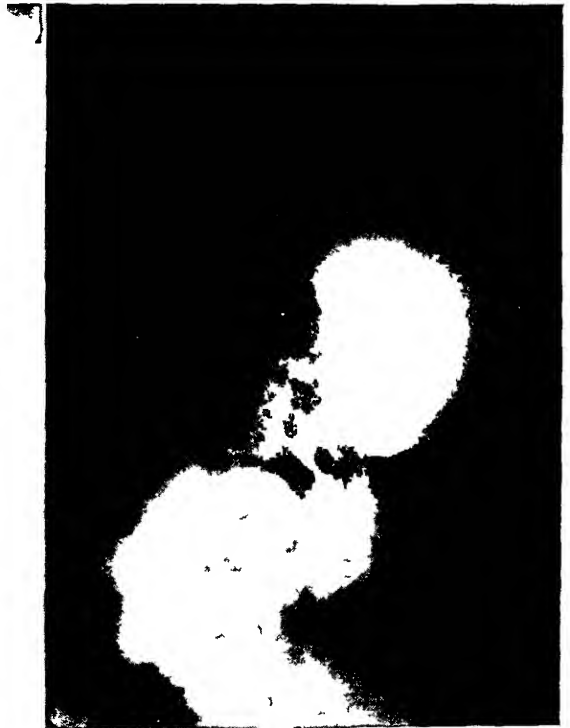


FIG 5—B Showing the same case, one year after a low resection of the Hoffmeister type by the author The jejunal ulcer is again to be seen, one inch from the stoma, with penetration into wall of the transverse colon Note narrowing of the stoma and the dilatation of the stomach Patient now convalescing after a high resection

The age and sex incidence is that usually found, namely, 42 males and 22 females Forty-four were between 35 and 50 years of age, and but one under age 30

The indications for operation and the selection of cases for surgical treatment are of the utmost importance The indiscriminate use of surgery in the treatment of gastric and duodenal pathology will lead to a large number of failures, and this is exceptionally true of duodenal ulcer

In this series of 64 cases, 24 exhibited pain, unrelieved by nonsurgical treatment, and 23 showed pyloric obstruction Pain was also a symptom in many of the obstructive cases Fourteen were operated upon on account of inability to eat and marked weight loss after one or more definite courses of

medical treatment In each of these cases roentgenograms showed a definite duodenal lesion

Three patients were operated upon following one or more perforations of ulcer sutured at time of perforation None has since perforated

The average duration of symptoms was five years, the longest 20, and the shortest two

In 22, or about one-third of the cases, I excised the ulcer I have noted no differences in the permanency of the cure between those excised and those untouched I believe those ulcers showing deep penetration and those resembling diverticula should be excised

Cholecystitis, with and without stones, was found at operation in 14 cases The gallbladder was removed Three cases had previously undergone cholecystectomy elsewhere One patient was later operated upon and is considered as a poor result

Immediate complications do not fall within the scope of this study except as they influence our second requirement The average time of hospitalization for the group was 23 days, and the longest, 92 days

Three of these patients have died since operation—one with cerebral hemorrhage, nine years after, one with coronary occlusion, seven years after, and a third with carcinoma of the transverse colon, nine years after

Thirteen cases have been followed ten years or longer, 25 from five to ten years, and 16 from one to five years

A review of the case histories of the poor results reveals a number of reasons for the failures, most of which were the result of surgical treatment In four of the five there was further involvement of the intestinal tract In the case of jejunal ulcer, posterior gastro-enterostomy was ill-advised due to the patient's general health

ABBREVIATED REPORTS OF FIVE CASES, CLASSIFIED AS POOR RESULTS

Case 1—Male, age 48 Had undergone cholecystectomy six years previously Indication for operation was failure of medical treatment for severe upper abdominal pain, inability to eat, progressive loss of weight and six-hour gastric retention

At operation a large indurated ulcer was found on the anterosuperior surface of the duodenum and marked duodenal deformity due to periduodenal adhesions This patient has regained normal weight His pain persists after six years and interferes greatly with his work Repeated examinations have failed to reveal a diagnosis

Case 2—Male, age 40 Twelve-hour gastric retention and pain, not relieved by medical treatment Operation included excision of ulcer Two years later, roentgenograms revealed a deformed duodenal cap and suggested recurrent duodenal ulcer At a second operation, chronic cholecystitis with numerous small stones was found, also numerous periduodenal adhesions Cholecystectomy was carried out The gastro-entero-anastomosis was healthy Patient is now well, five years later

Case 3—Male, age 38 Duration of symptoms eight years, 12-hour retention and emaciation Patient was treated medically on two occasions with hospitalization, but without relief of retention At operation two large ulcers, in apposition were found in the first portion of the duodenum They were not excised On the fifth postoperative day lobar pneumonia developed and was followed by empyema and phlebitis of both internal

saphenous veins This patient, five years later, is unable to work and has never recovered from the complications, although his digestion is entirely satisfactory This type of case must be classed as a failure because his present invalidism is a result of the operation

Case 4—Male, age 63 Operation for pain and inability to eat after six weeks' nonsurgical therapy and hospitalization This patient had had several breaks in cardiac compensation due to endocarditis, many years previously A large duodenal ulcer was found at operation and not disturbed Following operation, patient returned to hospital on frequent occasions, both on account of his heart condition and recurrent gastric symptoms He was finally admitted to the hospital, nine years after operation, with intestinal obstruction and died immediately following decompression *Autopsy* Ulcer at pylorus, jejunal ulcer, carcinoma of sigmoid with obstruction and vegetative endocarditis

This case illustrates the futility of gastric surgery in the presence of serious pathology other than that of the digestive tract I feel that it should not be attempted, except in the presence of gastric carcinoma

Case 5—Male, age 48 Operation after failure of nonsurgical treatment over a three-year period, and at patient's request Abdomen was never free from symptoms following operation, although nutrition became satisfactory and patient worked steadily Roentgenograms, taken six years after operation, revealed multiple diverticula of the sigmoid, which were not present in preoperative films

Gastric analyses have been made from time to time on a large percentage of these patients and the acidity has been uniformly low, and is apparently not of significance in this series

There have been cases which have presented occasional digestive upsets, transient in character, and in no case has there been malfunction of the stoma noted upon roentgenologic examination Repeated fluoroscopic examinations have shown rapid emptying through the stoma In many cases, small portions of the meal passed through the pylorus Apparently this has caused no untoward effect and I believe it is to be expected following any gastro-enterostomy

It is gratifying to note the willingness with which these patients have submitted to further measures thought necessary for complete rehabilitation and for prophylaxis against digestive diseases I have not urged dietary measures, but counsel the patients not to take foods which they have found from experience, do not agree I have been most insistent that they take no alkali or proprietary stomach pabulum after operation In my experience mineral oil has been most unsatisfactory after operation and I advise against its use If possible, any catharsis should be avoided

In this series tonsillectomy was carried out in 27 cases, dental hygiene and repair, including extractions, in 32 cases, appendectomy twice, hemorrhoidectomy, six times, and carcinoma of the breast, once One incisional hernia occurred and was repaired Large incisions are rarely necessary and should be avoided

Dr Eggers¹⁷ reports one case of carcinoma of the stomach after gastro-enterostomy None has developed in this series This is of interest, but perhaps of no significance

CONCLUSIONS

I have found that posterior gastro-enterostomy in the surgical management of duodenal ulcer has met certain requirements sufficiently to justify me in this continuance of its use. I have placed the stoma high in the body of the stomach for reasons which I have given, and which, to me, seem justified in the light of our present day knowledge of the physiology of digestion, as proven by well-planned experimentation. Duodenal ulcer of the chronic and nonbleeding type lends itself to nonsurgical treatment quite readily. Surgery will be limited to a well-selected group of cases in which these methods have failed.

REFERENCES

- ¹ Halsted. Surgical Papers
- ² Finsterer. Surg, Gynec, and Obstet, **68**, No 2A, 334, February, 1939
- ³ Marshall and Kiefer. J A M A, **109**, 1341-1346, October 23, 1937
- ⁴ Haberer. Deutsche Ztschr f Chir, 200-231, 1927
- ⁵ Lahey and Marshall. New Eng Jour of Med, No 24, 933-940, December 9, 1937
- ⁶ Lewisohn. J A M A, **106**, 684-687, February 29, 1936
- ⁷ Cutler, C W. ANNALS OF SURGERY, **108**, 68-83, July, 1938
- ⁸ Cannon and Blake. ANNALS OF SURGERY, **41**, 686, 1905
- ⁹ Ivy, A C. J A M A, **85**, 877, 1925
- ¹⁰ Cowgill, in Macleod
- ¹¹ Farrell, J I, and Ivy, A C. Am J Physiol, **78**, 325, 1926
- ¹² Fauley, G B, and Ivy, A C. Am J Physiol, **89**, 428, 1929
- ¹³ Ginsburg, *et al*. J A M A, **67**, 990, 1916
- ¹⁴ Ryan, Eric J. Personal communication
- ¹⁵ Schindler and Giere. Arch Surg, **35**, 712-765, October, 1937
- ¹⁶ Mann and Williamson. Am J Physiol, **63**, 403, 1922-1923
- ¹⁷ Eggers, Carl. ANNALS OF SURGERY, **108**, 84-104, July, 1938

CHRONIC DUODENAL ULCER*

PROCEDURES AS DETERMINED BY THE OPERATIVE PATHOLOGY

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A CONSIDERATION of the surgical treatment of chronic duodenal ulcer necessitates evaluation of the entire ulcer cycle, emphasizing the conditions which require operation. This is a highly controversial subject, and the present discussion will, therefore, be confined to the experience of one of us (J W H), with correlation of the preoperative phases and operative pathology in chronic duodenal ulcer.

Fogelson's collective review² of gastroduodenal ulceration, covering 1934, 1935 and 1936, cites 1,000 articles on the subject for each of those years. Therefore, one can substantiate any controversial point by the opinion of others.

In 1928, the Ulcer Clinic of the Fourth Medical and Surgical Divisions at Bellevue Hospital was organized. Since the organization of the clinic, no patient with chronic duodenal ulcer has been advised to have surgical intervention until all forms of medical treatment have been exhausted. Those patients who definitely required operation during the first five years were subjected to the time-honored procedure of gastrojejunostomy. The observations and impressions gained in the clinic in the surgical management of chronic duodenal ulcer form the basis of the present report.

During the 11 years from 1928 to 1938 inclusive, 960 patients with ulcers, either gastric or duodenal, were observed in the clinic. Many of these had previously been operated upon and were having a recurrence of symptoms—either due to the original ulcer or to complications from the operation. Of the total, 88.4 per cent of these patients were suffering from duodenal ulcers.

The vast majority of duodenal ulcers, if treated early, will respond satisfactorily to some form of medical treatment. The form of treatment depends upon the individual patient. No one form of treatment can be prescribed for all ulcers. If the Sippy regimen does not cause abatement of symptoms, other medical procedures must be tried before the patients are termed medical failures. Cooperation of the patient in the early stages of the disease is essential if surgery is to be avoided. The greatest aid in obtaining

* Read before the New York Surgical Society, April 12, 1939. Submitted for publication March 16, 1939.

this necessary cooperation is an intelligent explanation of the nature of the disease at the beginning of treatment

Most patients seen in the later stages offer a much less favorable prognosis than do those seen earlier. This is attributed to the infection in adjacent organs, in other words, we are dealing then with complications rather than with the original ulcer.

Indications for Surgery—Of the total number of previously unoperated cases in our clinic during the 11-year period, we have referred only 79, or 11 per cent, of 690 unoperated duodenal ulcers for operation. That in itself is most significant. The chief misunderstanding in discussing surgical failures in chronic duodenal ulcers arises from this fundamental point.

Proper interpretation of the patient's symptomatology is important in determining whether or not operation is indicated. This is *not* a point for the roentgenologist to decide. He can be asked only to determine the presence of an ulcer. If he finds it, that is as much as we should expect of him. However, some of the lesions which involve the posterior duodenum and particularly its second portion cannot be definitely diagnosed by the roentgenologist. He may be able to diagnose only a duodenal deformity, but this in itself may be more positive as an operative indication than the discovery of a definite niche.

A number of indications for operation are given in the literature, but we have accepted only one paramount indication for surgery in a patient with chronic ulcer—that is, uncontrollable pain. This is not the typical ulcer pain, but an atypical pain, more severe in character, usually necessitating sedatives and sometimes requiring morphine for its relief. It may be of a type to cause confusion with biliary tract disease, renal calculus, or even the abdominal crisis of tabes dorsalis.

Of the 86 patients operated upon, and reported in this paper, 83 per cent suffered severe pain, while the remainder had pain plus gross hemorrhage. The hemorrhage had been controlled before operation was advised.

Pyloric obstruction, as such, is not a true indication for operation, unless there is severe and uncontrollable pain. Obstruction without pain is usually due to spasm and not to organic stenosis. Antispasmodic medication and a milk and cream diet will usually cause emptying so that operation becomes unnecessary. Patients who have had pyloroplasties or simple closure for acute perforated ulcer may have organic obstruction without pain, but in patients previously unoperated on, our experience shows that organic obstruction is a most unusual complication in the absence of severe pain.

To repeat, therefore, we referred only 11 per cent of our previously unoperated cases for operation. This would indicate that most duodenal ulcers can be successfully treated by medical means. Our operative cases all gave long-standing histories, averaging 7.2 years.

Operative Pathology—The pathologic changes associated with long-standing duodenal ulcer clarify some of the points of confusion as to the surgical treatment. As previously stated, only the cases operated upon by the senior

author on the Fourth Surgical Division will be discussed in this communication

Eleven years ago, when surgery was indicated, gastrojejunostomy was considered the operation of choice. In 1933, a review³ of 79 gastrojejunostomies, followed for an average of four and one-half years, proved to be very discouraging. The incidence of marginal ulcer was found to be 16.4 per cent. The 960 ulcers under our observation have made 18,498 visits to the clinic.

A more recent review of the results of gastrojejunostomy in our clinic gives a still more dismal picture. Of 106 cases of gastrojejunostomy followed for 7.1 years, 24.5 per cent only were cured, 29.2 per cent were reported as improved and 46.2 per cent as unimproved. Thus nearly half the patients who had been subjected to this procedure had found their condition unchanged or worse. Of this latter group, 18.8 per cent had gastrojejunal ulcers and 7.5 per cent had questionable gastrojejunal ulcers.

We wish to emphasize that these patients had visited the clinic a total of 2,694 times, an average of 25.4 visits per patient. A report covering this phase of the subject will soon be submitted for publication.

As a consequence of these unfortunate results, we have, since 1933, submitted all chronic duodenal ulcers requiring operation to subtotal resection. Fifty-seven resections have been performed, of which 39 were primary and 18 secondary operations. From 1928 through 1932, the senior author had occasion to perform 29 gastrojejunostomies from our clinic. These two groups can, therefore, be compared as to the pathologic findings.

Of the 57 cases in which resection was performed, 72.8 per cent had posterior ulcers, 15.5 per cent had both anterior and posterior ulcers, and in 11.7 per cent the ulcer was anterior only. Among the patients with posterior duodenal ulcers, definite chronic pancreatitis of varying severity existed in 73 per cent. In some instances the head of the gland was 20 cm. in circumference. In all advanced pancreatic infections, the ulcer had perforated the entire duodenal wall and the pancreas formed the floor of the ulcer. The perforation in the duodenal wall was as great as 2 to 2.5 cm. In the milder cases there was a fibrous tissue partition between the ulcer and the pancreas, the serosa not being completely destroyed, but allowing direct extension of the infection to the interstitial tissue of the pancreas. In three instances, we have encountered definite jaundice as a result of the inflammatory reaction in the head of the pancreas, which made the diagnosis of an ulcer more confusing.

It is worth while emphasizing that the pathologic changes in posterior duodenal ulcer are not fully appreciated unless a subtotal resection is performed, with removal of the ulcer from the head of the pancreas. To determine whether a duodenal lesion is an anterior or posterior ulcer is most difficult, since a single posterior duodenal ulcer can cause a deformity on the anterior portion of the duodenum, that will give the characteristic appearance of an anterior ulcer. Subtotal resection definitely demonstrates the

posterior lesion. The deformity is due to scar tissue in the muscular layer of the duodenum giving the appearance of an anterior ulcer. This probably explains the poor results frequently obtained in pyloroplasties for chronic duodenal ulcer. What is taken to be the ulcer is excised from the anterior portion of the duodenum, but the real pathologic lesion (posterior) is left *in situ*. Even where an anterior ulcer is present, a posterior lesion often accompanies it. This occurred in 15.5 per cent of our cases. Such a posterior lesion is recognizable only by subtotal resection.

The fact that the main lesion is not attacked in gastrojejunostomy is the reason for the poor results in long-standing duodenal ulcers. We were then treating the complications, not the ulcer itself. Of the 29 patients in whom gastrojejunostomy was performed, 14 had anterior ulcers, 13 posterior ulcers with pancreatitis, and two had both anterior and posterior ulcers. Of the 39 primary subtotal resections for chronic duodenal ulcer, four showed anterior ulcers, 29 posterior ulcers with pancreatitis and six a combination of anterior and posterior ulcers, with pancreatitis (Table I).

TABLE I
ANALYSIS OF THE TYPES OF ULCERS

	Number of Cases	Anterior Ulcer	Posterior Ulcer	Both
Gastrojejunostomies	29	14	13	2
Primary resections	39	4	29	6

From a study of Table I, it would seem that the more advanced cases were selected for resection. However, the ages and duration of symptoms in the two groups were very similar. Both groups averaged 37.1 years of age, and the duration of symptoms were 7.1 years in the first group (gastrojejunostomy) and 7.3 years in the second group (resection).

In relatively late cases, pyloroplasty or gastrojejunostomy is unlikely to be satisfactory. First, because it deals with the complication resulting from the ulcer rather than with a primary lesion itself, and second, because a posterior duodenal ulcer is frequently left undiagnosed if a gastrojejunostomy is performed. Only subtotal resection provides adequate diagnosis in these cases. The difference is seen in the fact that more posterior ulcers were found in the group in which resection was performed, they were probably present in the others as well, but we had not been able to diagnosis them.

It is worth repeating that a true organic obstruction from chronic duodenal ulcer usually indicates a definite posterior ulcer with radiating scar tissue in the duodenal wall which has caused the stenosis. Pilcher,⁴ in 1913, called attention to this type of duodenal stenosis when he said "Posterior ulcers seldom perforate into the abdominal cavity, but are prone to inaugurate complications which, in the end, may prove quite as dangerous as an acute perforation, namely, pancreatitis, common duct obstruction and duodenal stenosis."

As previously mentioned, pyloric obstruction without pain is due to spasm

and can be alleviated by diet and medication. On the other hand, true stenosis of the duodenum, with pain, is a definite indication for subtotal resection. What has happened is: The ulcer in the posterior wall of the duodenum has perforated into the pancreas and caused chronic infection of that organ. Subtotal resection, but not gastrojejunostomy, is the proper method of attacking this condition.

Treatment—We do not advocate subtotal resection for the eradication of an existing gastritis or superficial gastric ulcer, because we have not encountered either. Neither is subtotal resection recommended on the basis that it produces achlorhydria. Its fundamental justification is the fact that it is the best means of eradicating the pathologic lesion and allowing the pancreatic infection to subside. In this respect the relationship of gastrojejunostomy to subtotal gastrectomy can best be compared to that of cholecystotomy and cholecystectomy.

It has been generally accepted that the mortality from gastrojejunostomy for chronic duodenal ulcer is relatively low, while the mortality from a primary resection is relatively high. We desire, therefore, to analyze our mortality rates following gastrojejunostomy, primary subtotal resection, and subtotal resections, as secondary operations for marginal ulcers or persistence of symptoms after pyloroplasty or gastrojejunostomy.

Gastrojejunostomy in chronic duodenal ulcer caused no deaths in the 29 cases in which it was performed, from 1928 to 1932 inclusive. Subtotal resection for primary duodenal ulcer in 39 cases, from 1933 to 1938 inclusive, resulted in two deaths, or a mortality of 5.1 per cent. Eighteen secondary resections following either pyloroplasty or gastrojejunostomy resulted in two deaths, or 11.1 per cent mortality. Two of the 18 had previously had pyloroplasties, three, simple closure for perforated ulcer, five had persistent symptoms from the original ulcer following gastrojejunostomy, eight had gastrojejunal ulcers. One of the two deaths took place in a subtotal resection following simple closure for acute perforation, the other occurred in an operation performed because of persistent symptoms following gastrojejunostomy.

Thus, in all, there were four deaths in the 57 subtotal resections for chronic duodenal ulcer, from 1933 to 1938, or a total mortality of 7 per cent.

Results of Operation—The literature on subtotal resection in chronic duodenal ulcer is most confusing, since a number of surgeons perform resections of the stomach, but leave the duodenal ulcer *in situ*. Although they class this procedure as resection for chronic duodenal ulcer, its results can hardly be as good as those following removal of the ulcer. One readily concedes that a live patient with complaints is better than a dead patient without complaints. Those who advocate leaving the ulcer *in situ* feel that the mortality is greatly lowered. This we question. In this entire group, we have removed the ulcer and our mortality rate has remained low. Leaving the lesion *in situ* fails to prevent leakage. Closure over the pyloric end of

the stomach or first portion of the duodenum may loosen the ulcer from the pancreas and in this way leakage will occur with a fatal peritonitis.

It seems contradictory that the larger the mass in the pancreas and the more marked the induration around the duodenum, the easier is the line of cleavage obtained about the duodenal stump. This is due apparently to the extensive fibrosis which results in thrombosis of the small vessels in the posterior duodenal wall, the branches of the superior pancreaticoduodenal artery. When the posterior wall of the duodenum is freed from this large inflammatory mass, relatively little bleeding is encountered. Therefore, the duodenal stump may be easily mobilized to permit closure without undue trauma. On the other hand, a small posterior ulcer which does not perforate the entire wall of the duodenum is sometimes more difficult to free than that of advanced cases, because the vessels have not been completely obliterated. Subtotal resections enable the ulcer to be completely freed from the pancreas and permit the duodenal stump to be closed.

From our follow-up, we have come to the conclusion that gastrojejunostomy and pyloroplasty are most unsatisfactory in the treatment of chronic duodenal ulcer. The adherent duodenal ulcer should be submitted to operation. Therefore, the procedure that offers the best results, considering mortality rate and permanent cures, is primary, subtotal resection with complete removal of the ulcer. Removal of the ulcer permits the associated inflammatory process, usually a chronic pancreatitis, to have an opportunity to subside.

COMMENT

When the incidence of operation in chronic duodenal ulcer is lowered to a point where approximately only one in 10 patients is operated upon, the results from gastrojejunostomy or pyloroplasty will be most unsatisfactory, as emphasized by Cutler¹. However, we are confronted with the problem of determining when the ulcer has ceased to be a simple, uncomplicated lesion, and has become adherent to an adjacent viscus, usually the pancreas. If we had some means of detecting a chronic infection in the pancreas, we might be able to select patients requiring surgery with more accuracy than has been possible in the past. We are now forced to rely on the presence of atypical pain with radiation directly to the back as our best means of making the diagnosis. The pain is very severe as compared with typical ulcer pain, and requires sedatives and rest.

We feel that the chief requirement in treating a patient with chronic duodenal ulcer is the maintenance of a dietary regimen over an indefinite period of time. A certain number of patients will have to be referred for operation, not because of the duodenal ulcer alone, but because of the complications arising from it. These would probably seldom arise if the lesion was recognized early, and if the patient would cooperate fully in his treatment.

The most satisfactory method of attacking the complicated duodenal ulcer is a subtotal resection. It offers a reasonable low mortality—a mortality

rate that compares favorably with that in other surgical procedures on the duodenum, such as pyloroplasty or gastrojejunostomy. It offers a better chance for permanent cure than either of the above procedures.

From our observations, one of the mistakes in any operative procedure upon the duodenum is to draw conclusions as to the permanency of a cure before a five-year period has elapsed.

The results of our gastrojejunostomies have been reviewed on two occasions, and those interested in a detailed report of our findings are referred to those reports.

As subtotal gastrectomy has only been performed during the past six years, and many more done in the past two to three years than in the earlier years of employing the procedure, any definite conclusions drawn at this time as to our follow-up would be premature and might be misleading. It is our intention after a few more years have elapsed to report our follow-up on subtotal gastrectomy similar to the reports on gastrojejunostomy.

REFERENCES

- ¹ Cutler, Condict, W., Jr. Changing Methods in the Surgical Treatment of Peptic Ulcer. *ANNALS OF SURGERY*, 108, 68-83, July, 1938.
- ² Fogelson, Samuel J. Gastroduodenal Ulcerative Disease. A Review of the Literature for the Years 1934 to 1936, Inclusive. *International Abstract of Surgery*, 65, 1-19, July, 1937.
- ³ Hinton, J. William, and Church, Reynold E. The Incidence of Gastrojejunal Ulcer Following Gastro-Enterostomy. *Surg., Gynec., and Obstet.*, 60, 65-73, January, 1935.
- ⁴ Pilcher, James T. The Diagnosis and Prognosis of Duodenal Ulcer. *New York State Jour. Med.*, 13, No. 10, 518-519, October, 1913.

PROBLEMS IN THE SURGICAL TREATMENT OF CHRONIC DUODENAL ULCERS^{*}

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THE author was responsible for bringing partial gastrectomy for the treatment of duodenal ulcers to this country. In 1922, he made a special trip to Innsbruck to learn from Haberer his technic in dealing with these ulcers. Immediately upon his return, the gastric group at Mount Sinai Hospital introduced this operation as the method of choice in place of gastro-enterostomy. Thus the author feels that he is in a similar position to Sir Francis Drake who brought the potato from this hemisphere to Europe. However, the similarity ceases at this point. For, whereas, the Europeans have been very happy with Drake's importation and have even put up a monument to him in praise of his deed, the author has not heard of any similar movement to erect a memorial to him for importing partial gastrectomy for duodenal ulcers into America. In fact, it is safe to say that this operation, during the last 16 years, has gained very slowly in popularity and that the vast majority of surgeons in this country are still opposed to this radical procedure.

We were ready to change from gastro-enterostomy to gastric resection for the following reasons. Nearly 20 years ago, at a time when gastro-enterostomy for the treatment of duodenal ulcers was still the most popular operation all over the country, the gastro-enterologic group at Mount Sinai Hospital, headed by Dr. A. A. Berg, had come to the conclusion that gastro-enterostomy was a bad operation. It was felt that many patients not only remained unimproved, but were made considerably worse by this operation. Our conclusions were not based upon general impressions, but upon exact figures compiled with great care from a very careful follow-up system. In brief, the study¹ demonstrated that 18 per cent of our gastro-enterostomies had already been reoperated upon for gastrojejunal ulcers, and another 16 per cent presented definite clinical and roentgenologic evidence of postgastro-enterostomy disease. When these figures were published in 1923, they were received with a great deal of scepticism. However, in recent years additional studies, from many different clinics, have been published, practically substantiating our statistics.

The attitude of American surgeons has changed considerably during the last 15 years. Up to a few years ago, those who dared to oppose gastro-enterostomy were ridiculed. At present it is safe to say, that with a few exceptions, surgeons all over the country concede that gastro-enterostomy for nonobstructive duodenal ulcers is an operation which should be avoided.

^{*} Read before the New York Surgical Society, April 12, 1939. Submitted for publication March 15, 1939.

While we are thus again on common ground with the rest of the surgical profession, we still differ materially as to what procedure should be substituted for gastro-enterostomy.

Many clinics in this country have returned to pyloroplastic methods (local excision of the ulcer, excision of the pyloric ring, gastroduodenostomy, etc.) These methods might solve the problem, if the duodenal ulcers were usually situated on the anterior wall of the duodenum. However, the majority of ulcers are found on the posterior wall, adherent to the pancreas. It is perfectly evident that pyloroplastic methods cannot be applied to these ulcers with any prospect of curing the patient.

There is another very important reason why pyloroplasties as well as gastro-enterostomies give unsatisfactory results. They do not change materially the acid values which existed before the operation. Clute and Sprague² conclude from their test-meal follow-ups after gastroduodenostomy that "the total and free acid, from months to years after operation, was nearly as high as, or was higher than it had been before operation." Thus, the door is left wide open for recurrences. For it is an undisputed fact that duodenal ulcers occur and recur in the presence of high acid values and that they are practically unknown in the presence of low acid values or an anacidity.

About 12 years ago, we reexamined an equal number of gastro-enterostomies³ and partial gastrectomies⁴ performed for duodenal ulcers. Whereas the gastric resections showed an anacidity or free HCl below 10 in 75 per cent of the cases, the gastro-enterostomies showed anacidity in only 4 per cent of the cases. The same test-meal (Ewald) was used in both series. In the vast majority of gastro-enterostomies the postoperative acid figures were not lower than those obtained before the operation.

Probably the most interesting group in this series were eight cases subjected to a partial gastrectomy following gastro-enterostomy with secondary gastrojejunal ulcers (Table I). All these cases showed a complete absence of free HCl after the gastric resection. In six cases, in which acid figures had been tested before the secondary operation, free acid varied between 19 and 68. In this group we have a very clear demonstration of the efficacy of gastric resection in achieving a postoperative anacidity, where a gastro-enterostomy had previously failed to reduce the original acid figures to any marked degree.

Let us face the problem squarely. It is conceded by practically everybody that production of a postoperative anacidity or postoperative low acid figures (free acid below 10) is the safest way to cure ulcer permanently and prevent recurrences. Furthermore, it is conceded by everybody with an extensive experience with ulcer patients, that neither gastro-enterostomy nor the pyloroplastic operations assure this desired reduction in the acid figures. It appears logical that in selecting an operative procedure for the cure of duodenal ulcers we should select that method which most frequently ensures a postoperative achlorhydria or at least marked reduction of the acid figures. The only method which produces this effect in the vast majority of cases is partial gastrectomy with removal of the lesion.

GASTRECTOMY FOR DUODENAL ULCER

TABLE I

SECONDARY PARTIAL OR SUBTOTAL GASTRECTOMY FOR GASTROJEJUNAL OR RECURRENT DUODENAL ULCER³

	Acidity Before Gastro-Enterostomy	Acid Figures Before Radical Operation	Partial or Subtotal Gastrectomy	Acid Figures After Radical Operation
B B	1910 Gastro-enterostomy for gastric ulcer	1918 40-60	1918 Partial gastrectomy for recurrent gastric ulcer	1923 0-20
S B	79-90-1920 Pylorectomy for pyloric ulcer	1923 40-45	1924 Subtotal gastrectomy for gastrojejunal ulcer	1925 0-28
M Z	1918 Excision duodenal ulcer, gastro-enterostomy plus pyloric exclusion 1920, removal of button	1920 68-88	1921 Partial gastrectomy for recurrent duodenal ulcer	1923 0-10
D G	90-100-1920 Excision duodenal ulcer, gastro-enterostomy	1922 19-55	1922 Subtotal gastrectomy for gastrojejunal ulcer	1923 0-20
M R	55-88-1919 Gastro-enterostomy for cicatrized pyloric ulcer		1920 Subtotal gastrectomy for retention	1923 0-27
S S	40-60-1915 Gastro-enterostomy plus pyloric exclusion for duodenal ulcer		1924 Partial gastrectomy for recurrent bleeding duodenal ulcer	1924 0-20
S P	61-77-1915 Gastro-enterostomy plus pyloric exclusion for pyloric ulcer Acidity before second operation 46-55, 1919 Excision gastrojejunal ulcer	1924 22-40	1924 Partial gastrectomy for gastrojejunal ulcer	1925 0-9
L K	1916 Gastro-enterostomy for duodenal ulcer, 1922 Excision gastrojejunal ulcer	1923 34-49	1923 Subtotal gastrectomy for recurrent gastrojejunal ulcer	1925 0-12

Why, then, does the opposition to gastric resection persist? It appears likely that it is based to a considerable degree upon certain technical difficulties inherent in the operative procedure. If gastric resection were technically as simple as gastro-enterostomy or pyloroplasty, every surgeon in this country would employ this method.

However, technical difficulties should never stand in the way of a popularization of a surgical procedure. Many years ago—indeed, in the memory of many of the older surgeons—cholecystostomy for cholelithiasis was praised and cholecystectomy was condemned as unnecessarily radical. Now, aside from a very few strict contraindications, cholecystectomy is the method of

choice, not as a cure-all, not as a source of relief from all symptoms, but as the best method available at present. With increased experience in this method, surgeons have learned how to avoid its pitfalls, and the mortality in chronic uncomplicated cases has been reduced from a very high percentage to a minimum. I hope that the younger generation of surgeons will practice partial gastrectomy for duodenal ulcers. I am sure that they will popularize the method in a comparatively short time.

Exaggerated statements have been made about the so-called inherent mortality and about the magnitude of the operative procedure in gastric resection. With some experience in gastric resection and with the proper

organization, the mortality in primary cases of gastroduodenal ulcers should not be higher than about 5 per cent. A number of surgeons (among many others, Bohmansson,⁵ Demel,⁶ Abumzant and Zabusova⁷) have published a large series of cases with a mortality of about 3 per cent. My own mortality for resection in primary cases of chronic gastroduodenal ulcers is 4.9 per cent (61 cases with 3 deaths). One of the best statistics was published by Koennecke,⁸ who reported 468 primary resections with a mortality of 1.5 per cent. Haberer⁹ and Duval¹⁰

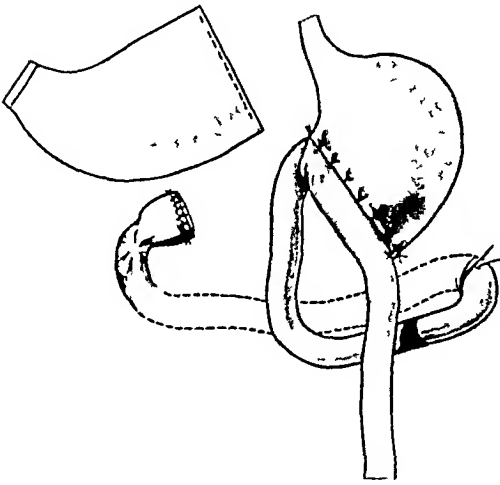


FIG. 1.—Palliative resection for deep duodenal ulcer (Finsterer 1918). Copied from Kirschner, Operative Surgery.

have published series of 100 consecutive gastric resections for ulcer without a death. I think it is safe to say that any major operation which can be employed in 100 consecutive cases without a mortality cannot be accused of having an inherent excessive mortality.

It is of interest to point out that the mortality following subtotal gastrectomy for gastric ulcers is usually higher than that following partial gastrectomy for duodenal ulcers. Yet, gastric resection for gastric ulcers is considered by most surgeons as a justifiable procedure, whereas gastric resection for duodenal ulcers is considered too radical.

I think the opposition is due to some extent to the abuse of the term, "subtotal gastrectomy" in the treatment of duodenal ulcers. The term "subtotal gastrectomy" infers that only a small stump of stomach is left behind. This term is fitting for the operation for high gastric ulcers. However, when dealing with duodenal or prepyloric ulcers the removed part represents a little more than one-half of the stomach, thus leaving a very considerable part of the stomach *in situ*. Partial gastrectomy is the correct term for this operation, not subtotal gastrectomy.

The term "gastric resection" is also incorrectly applied to certain operative procedures. Gastric resection means the removal of a little more than

half of the stomach with removal of that part of the duodenum containing the ulcer. Other operative procedures, for instance the Finsterer operation (Fig 1), should for very good reasons be specified as such and not called gastric resection. A very distinct and separate grouping of the Finsterer modification of a typical resection is of great practical value. For gastro-



FIG 2—Roentgenogram showing a gastrojejunal ulcer following an incomplete Finsterer resection

jejunal ulcers after the Finsterer operation are more frequent (according to some authors, 15 per cent after the prepyloric resection) than after a typical partial gastrectomy (with an incidence of recurrence of 7 per cent (Mage¹¹) following the latter operation) and less frequent than after gastroenterostomy (with about 30 per cent secondary ulcerations). Furthermore, the surgeon should distinguish between a prepyloric or a postpyloric Finsterer operation. Time does not permit a discussion of these different modifications

in detail Suffice it to say that when the pylorus is left *in situ*, the incidence of gastrojejunal ulceration is higher than if the pyloric ring was removed at the operation It must be stated that Finsterer never planned this operation as a routine procedure He employed it whenever an ulcer is not resectable without too great a risk (in less than 5 per cent of cases of duodenal ulcer in Finsterer's series)

As Finsterer has shown, his method of resection should comprise a removal of a large part of the stomach in order to compensate for the remaining pylorus In short, maximum protection against recurrences requires a high resection A few months ago the roentgenogram of a patient with a

gastrojejunal ulceration was shown to me The Finsterer operation had been performed by a gastric surgeon with considerable experience Yet the film (Fig 2) shows clearly that the surgeon, instead of performing a typical Finsterer, high resection, had performed a partial antiumec-tomy Under these conditions it is not surprising that a gastrojejunal ulcer developed in the short period of a few months, following the Finsterer "*Resektion zur Ausschaltung*"

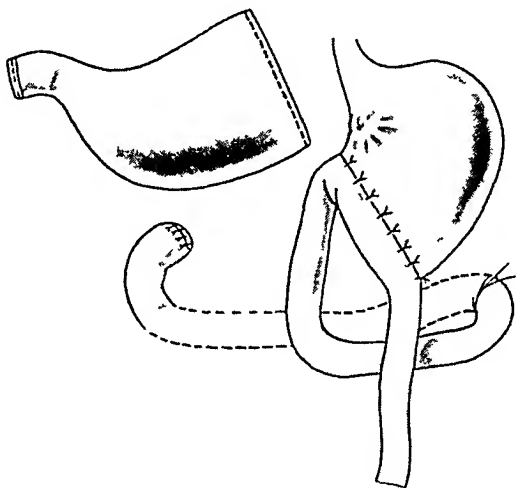


FIG 3—Palliative resection for high gastric ulcer
(Madlener¹² 1923)

aciduity considerably Thus this method has a sound principle The same cannot be said of the palliative resection of Madlener¹² (1923) who applied a similar principle to high gastric ulcers (Fig 3) As was to be expected, the postoperative results of Madlener's operation, when viewed in a large number of cases, were most unsatisfactory It is perfectly clear that in view of the fact that the food is not side-tracked, the ulcer is not put at rest Furthermore, operative acidity in gastric ulcers is usually low and does not so urgently require operative diminution The palpatory differentiation between gastric ulcer and cancer is often impossible If temporary cures follow this method, they probably occurred *independently* of the operation, not on *account* of the operation The picture of a life cycle of these ulcers (spontaneous disappearance and reappearance) is well known Some years ago I¹³ published a case with three life cycles, which I had occasion to observe over many years The Madlener operation was discarded many years ago and is very infrequently employed at present

A good many years ago—in the heyday of gastro-enterostomy—duodenal ulcer was considered a surgical disease At present, in view of the fact that gastro-enterostomy is in a condition of relative eclipse, and as a result

of the widespread reluctance to employ gastric resection, the pendulum has swung to the other extreme. To-day duodenal ulcer is considered by many doctors as definitely a medical disease. The serious complications of duodenal ulcer—mainly perforation and hemorrhage—seem to be more frequent in recent years because cases of duodenal ulcers are still considered a definite medical disease, even after repeated series of medical treatments have failed. We must take cognizance of the fact that a fair percentage of ulcer cases are refractory to medical treatment. In some instances the economic factor will put the ulcer patient into the surgical group. I am a strong believer in the attempt to cure ulcer cases medically. However, we must appreciate that surgery still continues to play an important rôle in this group of cases.

Has partial gastrectomy completely fulfilled the hopes which were expected from this operation? I think that judging the results quite impartially, we must confess that such has not been the case. While partial gastrectomy is far superior to gastro-enterostomy or pyloroplastic operations, it is not a definite and complete safeguard against a recurrent ulcer.

The ideal method for definite and permanent cure of chronic duodenal ulcers still has to be found. I think—possibly an interesting confession from a surgeon—it will be along medical, not surgical lines. At present we feel that when a series of medical treatments have failed, partial gastrectomy affords the best therapeutic method at our disposal. It relieves the patients of many years of suffering, safeguards them against the serious complications of perforation or hemorrhage, and effects a permanent cure in about 90 per cent of the cases.

REFERENCES

- ¹ Lewisohn. Frequency of Gastrojejunal Ulcers. *Surg, Gynec, and Obstet*, 40, 70, 1925.
- ² Clute and Sprague. Gastroduodenostomy for Certain Duodenal Ulcers. *J A M A*, 111, 909, 1938.
- ³ Lewisohn and Feldman. Failure of Gastro-Enterostomy to Effect a Decisive Reduction in Gastric Acidity. *ANNALS OF SURGERY*, 82, 925, 1925.
- ⁴ Lewisohn and Ginzburg. Relation of Postoperative Achlorhydria to the Cure of Gastric and Duodenal Ulcers. *Surg, Gynec, and Obstet*, 44, 344, 1927.
- ⁵ Bohmansson. Personal communication.
- ⁶ Demel. Zehn Jahre Magen Chirurgie wegen peptischen Geschwüers. *Centralbl f Chir*, 62, 2185, 1935.
- ⁷ Abramzant and Zabusova. Diagnosis and Treatment of Gastroduodenal Ulceration in Relation to Occupation and to Living Conditions. *Vestnik Khirurgii*, 39, 95, 1935, (Abstr.) *J A M A*, 106, 84, 1936.
- ⁸ Koennecke. Misserfolge nach Ulcusresectionen. *Chirurg*, 3, 873, 1931.
- ⁹ Haberer. Gegenwärtiger Stand der operativen Behandlung des Magens u. Zwölffingerdarmgeschwüers. *Deutsch Ztschr f Chir*, 200, 231, 1927.
- ¹⁰ Duval. 100 Gastrectomies pour ulcère sans mortalité. *Mem Acad de Chir*, 62, 543, 1936.
- ¹¹ Mage. Medical Fortnightly of the N. Y. Academy of Medicine, 1935.
- ¹² Madlener. Über Pylorotomie bei pylorusfernem Magengeschwür. *Centralbl f Chir*, 50, 1313, 1923.
- ¹³ Lewisohn. Life—Cycle of a Gastric Ulcer. *ANNALS OF SURGERY*, 94, 148, 1931.

DISCUSSION DR MORRIS K SMITH (New York) said that one of the interesting trends in surgical opinion as it has found expression in the New York Surgical Society as well as elsewhere over a period of years has been the swing away from gastro-enterostomy in the treatment of ulcer. It would be a sad state of affairs if thought remained static and the surgeon satisfied with things as they are. On the other hand, the pendulum often swings far, and there is danger perhaps in coming to underestimate the value of an operation which has proven its worth time and again. For this reason Doctor Smith was particularly glad that Doctor Westermann had presented the case for gastro-enterostomy in the treatment of chronic duodenal ulcer, emphasizing two points, namely, the location of the stoma and the results obtained.

The high location of the anastomotic stoma in the stomach advocated by Doctor Westermann was of interest to Doctor Smith because there has not been much emphasis on it. Walton, in Nelson's Loose Leaf Surgery, states that in cases of marked acidity he places his anastomosis higher in order to secure a better admixture of the neutralizing duodenal contents. Doctor Westermann has given some interesting reasons for his preference for keeping the stoma well to the left, feeling that this prevents distention of the stomach and tends to prompt and more satisfactory emptying. It would seem as if a study of the emptying time and acidity in a comparable series of high-lying stomata on the one hand and antrally placed gastro-enterostomies on the other might help to settle the question.

In evaluating his results, Doctor Westermann made the point, as have other writers, that the indications for the operation should be carefully considered. Some of the dispute into which gastro-enterostomy has fallen is due to the readiness with which both surgeons and medical men, some years ago, advised operation once the diagnosis of duodenal ulcer was made. Often the patient was as prone to symptoms afterwards as before. To-day there is universal agreement that the condition is ordinarily best handled by medical measures and that surgery is for the exceptional, not the average case.

The results reported by Doctor Westermann were good, and if a large proportion of these patients had been submitted to radical stomach surgery, some of them might well have succumbed to the operation.

Stimulated by Doctor Westermann's paper, Doctor Smith looked over his own late results of gastro-enterostomy for duodenal and pyloric ulcer. They include some gratifying successes and disappointing failures. The former give the assurance that the operation, properly chosen, can be effective. Improvement will come from better selection of cases for operation and perhaps more discrimination in the choice of operative procedure in the individual case.

DR JOHN A MCCREERY (New York) recalled the various papers on this subject that had been presented during the past few years before the New York Surgical Society. He thought that it was interesting that so many different points of view should be held by members of the society. It seemed to him that some of the differences in view-points might be due to difficulty in interpreting patients' symptoms.

The evaluation of abdominal discomfort and "indigestion" is difficult, varying so much as it does with the patients' reactions. In his own experience many patients were free from symptoms following gastro-enterostomy, except after food indiscretions or (in one case) during pregnancy. Should symptoms in such cases be thought of as due to ulcer or to patients' lack of control? He had the feeling that the advocates of gastrectomy were sometimes too harsh.

in their feeling that gastro-enterostomy was a failure unless the patient was completely and permanently free from gastric symptoms following the operation

Doctor McCreery agreed with Doctor Lewisohn that future progress in the solution of gastroduodenal problems lay in medical rather than surgical fields and, above all, in the discovery of the cause of ulcer

The experience of the men working in the First Division Gastric Clinic at Bellevue had been much the same as Doctor Hinton's. A surprisingly small percentage of cases came to operation, the rest being kept comfortable under dietary regimen, even in the low economic level cases cared for in a city hospital. Doctor McCreery felt that one aspect of the nonsurgical care of these cases was not sufficiently stressed—the psychologic sides of the patients' difficulties. It had been the experience of his associates that the patients were often helped most by the opportunity of sitting down with a physician whom they had known before and for whose advice they had respect, and talking over their economic and social difficulties. This had impressed him so much that he had often felt that the addition of a member of the psychiatric clinic would be of great benefit to his organization.

Doctor McCreery disagreed with Doctor Hinton as to the nonsurgical treatment of definite chronic obstruction, feeling that these cases should have early rather than late surgical relief. He also felt that there was a group—particularly in the city hospital level—who are unable or unwilling to follow a regimen of any strictness but who were much more amenable to advice following operation.

A recent review of cases of duodenal ulcer, operated upon by the members of the staff of the First Division of Bellevue, in whom a gastro-enterostomy had been performed, showed 60 per cent results satisfactory both to the physician and to the patient, 10 per cent with symptoms due to persistence of the original ulcer, and 10 per cent with marginal ulcer.

Doctor Hinton spoke of the importance of removing the ulcer and thought that postoperative disappearance of acid was not important. It probably is true that removal of the ulcer is of primary importance, but Doctor McCreery noted that Doctor Hinton usually carried out a more extensive gastrectomy than would be required for the removal of the ulcer and he (Doctor McCreery) felt that this was a wise procedure as a step in the prevention of marginal ulcer.

DR THOMAS H. RUSSELL (New York) said that if he were to ask the residents on the Surgical Service at the Post-Graduate Hospital what operation should be performed for chronic duodenal ulcer, he felt sure they would reply "subtotal resection of the stomach"—for the reason that they have seen so many bad results following an operation of gastro-enterostomy which had been performed elsewhere.

Doctor Russell agreed with both Doctors Lewisohn and Hinton in emphasizing the importance of always performing a high resection. Many of the cases reported as having had a gastrojejunal ulcer following a subtotal resection have followed pylorotomies and not subtotal resections of the stomach.

Doctor Russell said that for almost three years he had performed the gastric surgery on the service cases admitted at the Post-Graduate Hospital and felt sure that the mortality rate had been reduced as a result of having the stomach cases assigned to one service. The mortality rate last year was slightly under 5 per cent. The Ulcer Clinic has given Doctor Russell more trouble than any clinic in the Surgical Department, largely because of emphasis upon the importance of medical treatment in cases of ulcer, both gastric and

duodenal—so much so that patients with carcinoma, which is sometimes overlooked, are treated in the clinic too long and not referred for surgery until too late. The question of differential diagnosis between carcinoma and ulcer is a most important one and cases should have the advantage of an exploratory operation.

The Medical Department, on ulcer cases, has been greatly improved by the assistance of the Social Service Department, who send their workers to the patients' homes and instruct the wives of the patients in the preparation of food, and who emphasize the importance of regular feedings and, what is perhaps more important, abstinence from smoking and alcoholic liquors.

DR HUBLEY R. OWEN (Philadelphia) said that whereas he agreed with Doctors Hinton and Lewisohn regarding the fact that "once a gastro-enterostomy always a gastro-enterostomy," yet he did not believe this operative procedure could be thrown into the discard. There are many cases which require rest to the ulcer-bearing area which can be benefited by the short-circuiting operation of gastro-enterostomy—patients who are not sufficiently strong to stand the more radical procedure of gastric resection. There is no doubt gastric resection is a more serious procedure than gastro-enterostomy, and for this reason Doctor Owen said he had not as yet had the temerity to follow Doctor Lewisohn's footsteps in performing so large a percentage of resections.

Doctor Owen said that he had been interested to hear Doctor Westermann say that he does not use clamps in his gastro-enterostomies. He recalled many years ago when he had the privilege of assisting Doctor Da Costa, he neglected to have clamps sterilized for a gastro-enterostomy. Doctor Da Costa always held his fist assistant and not the head nurse of the operating room responsible for the selection of instruments. When Doctor Da Costa asked for the gastro-enterostomy clamps the head nurse stated they had not been sterilized. Doctor Owen said he almost lost his job then and there but Doctor Da Costa proceeded to perform the gastro-enterostomy without clamps and never used them thereafter. Neither, said Doctor Owen, had he.

Doctor Owen said that there had come under the care of himself and his associates a large group of men, some 10,000, during the past 30 years, and so they had had their share of operative procedures for duodenal ulcer. There has not been as high a percentage of postoperative jejunal ulcers as the statistics presented by Doctors Westermann, Hinton and Lewisohn would indicate. The opening in the stomach is made lower than shown by Doctor Westermann, it is made nearer the greater curvature and closer to the pylorus.

A case was cited to demonstrate one of the mistakes of a gastro-enterostomy. Doctor Owen operated some years ago upon a policeman for duodenal ulcer. His reaction to the operation was satisfactory for several months. Then his symptoms returned. Roentgenologic examination showed the jejunum to be distended to about the size of a normal stomach, whereas the stomach was contracted to about the normal size of the jejunum. The opening of the gastro-enterostomy was too large. Doctor Owen reoperated upon the patient. The ulcer was healed. He took down the gastro-enterostomy. The patient has had no recurrence of his symptoms of duodenal ulcer.

Doctor Owen concurred that chronic deformity of the duodenum associated with six-hour gastric retention and a low acidity is certainly an indication for gastro-enterostomy.

Great difficulty is frequently experienced in attempting to separate the duodenum from the pancreas in adherent penetrating ulcers. However, it is not necessary to mobilize the duodenum in this type of case. The duodenum

may be closed proximal to the ulcer and a Pólya or Hofmeister partial gastrectomy performed. Doctor Owen said that he frequently performs a palliative gastro-enterostomy after a second hemorrhage from duodenal ulcer on those patients who cannot stand the more radical operation. He did not believe gastric resection to be indicated in the chronic ulcer associated with hyperacidity and in those patients who are sufficiently good operative risks. Just before his present service at the Philadelphia General Hospital, since January 1, 1939, four partial gastrectomies have been performed satisfactorily.

DR EDGAR BURKE (Jersey City) had been much impressed by Doctor Westermann's experiences because they have been so different from the experience at the Medical Center in Jersey City, where a very large material is seen and a very meticulous effort made to follow it up. The marginal ulcer statistics have not been quite as prohibitive as those mentioned in the present symposium. The most honest average that has been arrived at is between 8 and 9 per cent. However, that is regarded as bad, so bad that the operation of gastro-enterostomy is avoided, at all costs, if this is possible. However, it is employed in the clinic under two sets of circumstances. In cases of pyloric stenosis, due to a *thoroughly healed* ulcer, which show relatively low acid values and a ptosed, dilated and atonic stomach. In this type of patient the results have been excellent. The other indication is acute perforated ulcer at or near the pylorus where the induration and friability are so extensive that wide imbrication has to be resorted to, which obviously results in a nonpatent pylorus. Here the procedure is employed not electively but under compulsion. It is easy, in this type of case, to be too pessimistic. "Oh," it is said, "*nothing* will go through *this* pylorus!" Very often it will! But, of course, there will always remain a small group of cases which, when safely and properly closed, will be occluded, making some form of short-circuiting mandatory at the time of operation.

The trend in the Jersey City Medical Center Clinic has been, in the past 14 years, very definitely in one direction—fewer operations for duodenal ulcer, but more radical ones. Very reluctantly, as the result of experience, the surgical staff has seen itself pushed farther and farther toward what might be referred to as "the Mt. Sinai teaching"—that is, radical operation. Operation for chronic duodenal ulcer on Doctor Burke's service to-day means subtotal gastrectomy. The gastric surgery has been concentrated in a few hands because of the conviction that, in this particular field of therapeutic endeavor "many cooks spoil the broth."

DR CARL EGGERS (New York) said that it was most interesting to contemplate that three men, representing hospitals of New York with similar material, should arrive at such opposite viewpoints. Doctor Westermann's experience with carefully observed patients, followed over a period up to 20 years after the conservative operation of gastro-enterostomy, corresponds with the experience at Lenox Hill Hospital. His statement regarding the physiology of the stomach and his emphasis on attention to technical detail merit consideration. He has seen only one case of postoperative jejunal ulcer. Compare that with Doctor Lewisohn's figure of 33 per cent. What is responsible for this difference?

If there is one thing that has been learned to-night, it is to operate upon fewer cases with duodenal ulcer. The three papers presented, as well as those recently read before the N. Y. Surgical Society by Doctors Condict, Cutler and Eggers stress this point. One of the errors committed years ago, was that operation was frequently undertaken on the mere diagnosis of duodenal ulcer. It had apparently been forgotten that gastro-enterostomy

was conceived as an operation for the side-tracking of gastric contents in cases with pyloric obstruction. For such a condition it was most successful, and for such conditions it is most successful to-day. It was the application of the operation to patients with simple, uncomplicated, frequently acute duodenal ulcer that led to unsatisfactory results. If some degree of obstruction exists, and in older individuals with a chronic ulcer, the operation has given excellent results. The great majority of Doctor Westermann's cases were over 35 years of age. Doctor Lewisoohn did not mention the age of his cases.

Doctor Eggers said he believed in radical surgery when indicated, but that one must get away from the idea that when operation for duodenal ulcer is indicated, it must be a radical one.

Doctor Hinton mentioned that of his large series only 11 per cent had been operated upon. Only the worst cases, with complications such as intractable pain and repeated hemorrhages, were selected. Even the advocates of gastro-enterostomy as a method of treatment in selected cases of chronic duodenal ulcer are inclined to perform a radical operation in this type of case. Doctor Hinton rejects pyloric obstruction as an indication for operation, because he considers it unnecessary. Doctor Eggers felt that a conservative operation for the relief of symptoms may be extended to a larger group of chronic sufferers than Doctor Hinton has done.

At Lenox Hill Hospital the percentage of cases selected for operation has always been low because of association with a group of men who felt and taught that duodenal ulcer in a young patient is a medical disease. Only when a chronic ulcer produced recurrent symptoms which incapacitated the patient, or when complications developed, or pyloric obstruction supervened, was it considered an indication for surgery. By this time, the patients were in the older age groups, the acidity was usually lower, and they presented a different picture from early acute ulcer. In those cases, gastro-enterostomy was then, as it is to-day, a very valuable operation. One should not be too ready to discard it.

Doctor Eggers recently operated upon a man who had had a gastro-enterostomy performed by Doctor Peck some 25 years ago. The patient was well for many years and then developed recurrent ulcer symptoms. At one time, a marginal ulcer had been diagnosed roentgenologically. During the past summer he had several severe hemorrhages. Transfusions were given. When first seen by Doctor Eggers he was quite exsanguinated. An emergency operation was performed—a resection by the Billroth II method, proximal to the old gastro-enterostomy. The lesion which produced his symptoms was the old recurrent duodenal ulcer, situated on the posterior surface and adherent to the pancreas. There was no scarring of any other ulcer. The very much contracted gastro-enterostomy opening had smooth margins and on microscopic examination was found to be completely epithelialized. A roentgenologic diagnosis of marginal ulcer should not be trusted too much.

Doctor Eggers felt that a conservative attitude should be maintained regarding the surgical treatment of duodenal ulcer, and that the interest of patients is best served by not making subtotal gastrectomy for chronic duodenal ulcer a routine procedure.

DR SIGMUND MAGE (New York) said that for ten years he had been following the cases of peptic ulcer resected by partial gastrectomy at the Mt Sinai Hospital Gastric Clinic, and that he was not amazed, as Doctor Eggers seemed to be, that the three speakers do not agree. Doctor Mage said that he could not completely agree with Doctor Lewisoohn, a statement which he qualified by explaining his own particular attitude toward the unsettled status

of partial gastrectomy and gastro-enterostomy Under existing conditions, the statistical results with these operations from different clinics cannot be logically compared, and one's results with any particular therapeutic measure are more apt to be reflective of an experience with a particular aspect rather than with ulcer disease as a whole Doctor Mage said he had been on Doctor Berg's Gastric Service, on Doctor Lewisohn's Gastric Service and that he is now on Doctor Colp's Gastric Service, and that it is his impression that the inherent mortality of partial gastrectomy for primary chronic duodenal ulcer is greater than Doctor Lewisohn ascribed to it in his paper Doctor Mage said that the fact that two men from the same clinic cannot agree on a matter of this kind illustrates a type of difficulty that has served to keep the problem of partial gastrectomy and gastro-enterostomy unsettled for the past two years One of the main reasons for the persistent disagreement in that problem has been a failure to talk about the same things and to define specifically what is meant The disagreement between Doctors Lewisohn and Mage relates in part to different interpretations of inherent mortality Doctor Mage said his impression of the inherent mortality of partial gastrectomy for primary chronic duodenal ulcer at the Mt Sinai clinic is the percentage incidence of such cases which have died as a result of that operation, when performed by trained gastric surgeons, who had given due consideration to the ordinary contraindications, which one respects in employing a major surgical operation In a series of 340 primary, chronic duodenal ulcers, subjected to partial gastrectomy, Doctor Mage found 31 deaths, which to Doctor Mage indicated an inherent mortality of 9.1 per cent If Doctor Lewisohn hopes the young surgeon will embrace partial gastrectomy and imposes a fixed inherent mortality of 5 per cent upon him, it is reasonable to ask what he means by that inherent mortality If he disregards the experience of the Mt Sinai Clinic, and resorts for the support of his view to the experience of surgeons in other clinics, of whose material nothing personally is known and whose operations in some instances are not the same as the one performed at Mt Sinai, Doctor Lewisohn should indicate his experience with subtotal gastrectomy with chronic duodenal ulcer His mortality figures in his paper relate to primary gastric duodenal ulceration, which include gastric and duodenal cases and do not indicate the number of duodenal ulcers—the subject of this symposium He should mention the actual number of primary chronic duodenal ulcers upon which he has operated, the number of deaths, and what cases he excludes in evaluating mortality results Doctor Mage said further that Doctor Lewisohn had quoted him on the end-results after subtotal gastrectomy Inasmuch as those results related to a large experience in which the mortality was between 8 and 9 per cent, it is only fair that Doctor Lewisohn give the end-results of his own experience Doctor Mage felt that Doctor Hinton should also give his end-results with partial gastrectomy It is illogical to assume that, just because gastro-enterostomy is a poor operation, subtotal gastrectomy is necessarily a better one One must show proof of that

Doctor Mage said that no doubt he would seem to be hypercritical He has been so in evaluating the results at Mt Sinai, but unless surgeons are critical of their own results, and are willing to recognize and admit the fallacies in their statistics with the same readiness that those fallacies are granted in the statistics of others, the possibility is that this problem will continue to be argued for another 20 years or more

DR JOHN J WESTERMANN, JR (closing) said that a significant fact in the question of jejunal ulcer is that he has found, from the records of St Luke's Hospital, that but eight cases have been admitted during the past five

years in which jejunal ulcer was definitely proven. Of these, four, or 50 per cent, occurred after partial resection where one-half or more of the stomach remained after resection. Unless a resection includes at least 70 per cent of the stomach, the incidence of jejunal ulcer will be as high or higher than after posterior gastro-enterostomy.

DR J. WILLIAM HINTON (closing) said that of several important points brought out in the discussion of the papers, one of the most important was that mentioned by Doctor McCreery with regard to the psychologic handling of these patients. Without question if the patient with duodenal ulcer when seen has his disease explained to him, one will get cooperation during his medical case, and cooperation is the most important factor in the whole medical regimen. It is also very helpful to have him come back and talk to someone in whom he has confidence.

In answer to the question as to why he removes so much of the stomach when there is a question in mind as to whether the anacidity produces the good results, Doctor Hinton admitted that in all probability he is wrong in his assumption that anacidity is not playing the important part. Therefore, he gave the benefit of doubt to all of those who maintain that by producing anacidity they will cure the patient. But Doctor Hinton himself felt that it is getting rid of the pathologic process that is present that gives the good results. As a matter of fact, it is as easy to remove 70 per cent of the stomach as to remove 25 per cent.

With regard to the question of healed ulcer, mentioned by Doctor Russell, Doctor Hinton said he had never found one that had healed. In his experience if an ulcer has obstruction without pain, it is a medical problem.

Doctor Hinton said that he concurred in the statement that there is still a place for gastro-enterostomy or gastrojejunostomy, but that in the last six years he had not found that place.

Concerning follow-up results in subtotal resections chronic duodenal ulcer, the statistics presented cover only six years. Whether there has been justification for the subtotal resection is not yet certain, but it is certain that from the figures there would not have been justification for performing a gastrojejunostomy, a questionable procedure. Doctor LewisoHN once stated that gastro-enterostomy is not an operation but a disease, and he modestly declines the originality of this statement, but credits it to some of his European friends, nevertheless, that, said Doctor Hinton, is his feeling from observation and experience, namely, that it is more of a disease than an operation.

DR RICHARD LEWISOHN (closing) recalled that Doctor Hinton had stated that only 10 per cent of duodenal ulcers are on the anterior wall and that the others are either double ulcers or on the posterior wall. It is impossible to excise an ulcer on the posterior wall. Thus excision of the ulcer is possible in a small number of cases only. Doctor Westermann ascribed his good results with gastro-enterostomy, among other reasons, to the fact that he uses catgut as suture material and does not use clamps in performing the gastro-enterostomy. In the early days when many gastro-enterostomies were performed at Mt. Sinai Hospital, Doctor Berg used the Pagenstecher non-absorbable suture and Doctor LewisoHN used catgut only. Yet the incidence of gastrojejunal ulcer was as high in Doctor LewisoHN's series as in Doctor Berg's. Doctor Lahey has performed gastro-enterostomies without clamps for years. Yet he has observed many gastrojejunal ulcers.

In a recent paper Mr. Ogilvie said "People always call gastro-enterostomy the 'conservative operation' and gastric resection the 'radical operation,'" and suggested that these terms are not correct. Gastro-enterostomy should

be called the "incomplete operation" because it is followed by many complications and recurrences. Gastric resection should be called the "thorough operation."

In answer to Doctor Eggers' questions, Doctor Lewisohn said that the majority of patients were under 60 years of age. He was under the impression that about 10 to 12 per cent of the ulcer patients seen, either on the wards or in the dispensary, were operated upon.

Doctor Lewisohn said that for many years he had been of the opinion that gastro-enterostomy was a good operation for healed duodenal ulcer with stenosis. But he has changed his viewpoint for two reasons. First, it is impossible to state definitely by palpation whether or not an ulcer has healed, second, alarming symptoms of postoperative atony are sometimes encountered. These cases with practically complete obstruction have very large stomachs and the propelling power is not sufficient to carry the food from the stomach into the intestines. A good many serious complications have arisen as the result of performing a simple gastro-enterostomy in complete obstruction, where it was thought that one was dealing with a healed ulcer.

Doctor Lewisohn disagreed with Doctor Mage that it was incumbent upon him to include in his mortality statistics those of other men on the same service. A surgeon is not responsible for any surgery performed by others, especially as this may include the work of younger men with less experience. He has always stated that he was quoting his own mortality, from his first case up to the present time. It is impossible to compare surgery of this sort unless one adheres to one's own personal experience. Dr. Lewisohn said that he had performed 36 gastric resections for duodenal ulcer with two deaths, a mortality of 5 per cent. Not included in this group are secondary cases—a secondary case being one which has had a previous operation upon the stomach or duodenum, for instance, a suture of a perforated ulcer, a pyloroplasty, or a gastro-enterostomy. Cases of bleeding ulcers, in which one or more active hemorrhages played an important rôle in the clinical picture, are not included in these statistics. The subject under discussion in this symposium is chronic peptic ulcer.

PERFORATIONS OF THE GASTRO-INTESTINAL TRACT*

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PART ONE

"The sun must never rise or set in perforations of the gastro-intestinal tract without an attempt at relief" This dictum draws attention at once to the fact that perforations of the gastro-intestinal tract are always serious as to prognosis. They must be considered either as an emergency or an urgency. The higher (esophagus) or lower (colon) in the gastro-intestinal tract the perforation occurs, the more serious the outlook. Mortality is very high and the chance of the patient's recovery is problematic unless an early diagnosis is made.

In emergencies, operation must be immediate in order to save the patient's life. In urgencies, a short time may be taken to refine the diagnosis with roentgen and laboratory examinations, so that operation may be performed with a definite diagnosis. Fortunately, emergencies are fewer than urgencies. In the urgent cases, diagnosis is made from the general clinical picture, including a careful history and physical examination. There is dull, aching and constant pain accompanied by shock which may have come on immediately after the perforation—be that accidental or spontaneous—or may be delayed and gradual in onset. The pulse is rapid and thready, the blood pressure low. Nausea and vomiting may be present. If vomiting continues, perforation of some organ must be seriously considered. Tenderness will be diffuse and early muscular spasm will occur. Distention is usually an unfavorable sign, as it may mean general peritonitis and sepsis. Shifting dullness in the flanks may point to intra-abdominal hemorrhage—usually due to injury of a solid viscus or rupture of a mesenteric vessel. Hemorrhage is shown in the blood count by a fall in the red blood corpuscles and hemoglobin, and an early elevation of the white blood corpuscles. Peritoneal irritation is indicated by a rise in the white blood corpuscles and polymorphonuclear leukocytes. Obliteration of liver dullness means rupture of a hollow organ. If the pulse rate rises progressively, it is an indication not to postpone operation.

Perforations of the gastro-intestinal tract may be classified as (1) Percutaneous injuries through the abdominal wall brought about by bullets, knives, etc., and (2) subcutaneous perforations caused by inflammatory or malignant erosion, by pressure generated within an organ, by blunt force applied directly or indirectly to the abdominal wall, as in falling, lifting or straining. Diagnosis is often difficult due to the absence of evidence of abdominal wall injury.

*Read before the New York Surgical Society, March 1, 1939. Submitted for publication, February 12, 1939.

GASTRO-INTESTINAL PERFORATIONS

The discussion in this communication is based upon a series of 151 cases of perforation seen at the Lenox Hill Hospital, from 1923 to 1938. We will include perforations of the entire gastro-intestinal tract, but will exclude perforations of the appendix and gallbladder. Perforations of the esophagus had the highest mortality (87.5 per cent), while those of the colon had twice the mortality (66.6 per cent) of gastric and duodenal ulcers. The mortality for all areas is shown in Chart I.

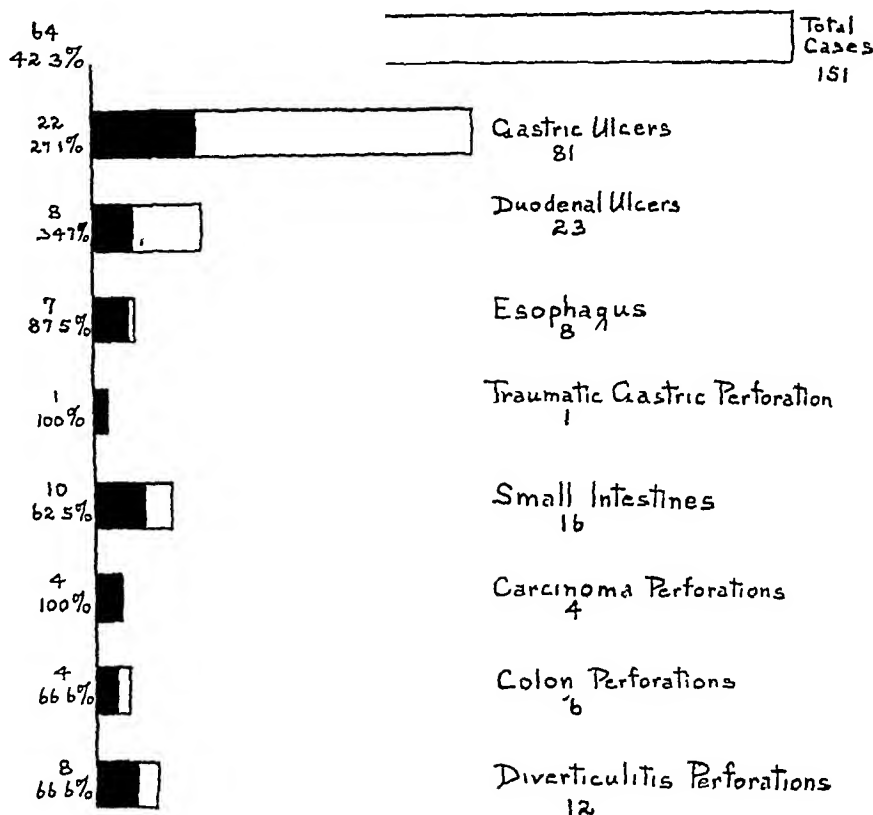


CHART I—Showing, graphically, the mortality rate from perforations in all parts of the gastro-intestinal tract.

Perforations of the Esophagus—Queisant^{1, 2} reports a case of a girl age 7, who ruptured her esophagus while vomiting. Such cases rarely come to roentgenologic examination, as perforation gives rise to such serious situations that roentgenologic study is inadvisable. Sigora³ reported the rupture of an esophageal diverticulum just below the bifurcation of the trachea in a child, age 7. In this case a contrast meal was given. Some of it entered the stomach and some was seen to run through the perforation in the diverticulum into the free pleural cavity, whence it quickly reached the costophrenic sinus.

In 1837, Heyfelder reported the case of a patient who ruptured his esophagus during a convulsion and died. Williams mentions a case in which not only the esophagus but the diaphragm as well was ruptured during vomiting. Gross⁴ cites the case of a man, age 30, who gave exhibitions of sword swallowing and injured his esophagus to such an extent as to cause perforation with abscess formation and death. Gamble⁵ recently published a

most interesting report on congenital tracheo-esophageal fistulae, with a new method of operative procedure. This condition is due to atresia of the esophagus with tracheo-esophageal fistula. It occurs infrequently.

All of the ruptures mentioned were linear. Boerhaave, in 1724, reported a unique case in which the rent was transverse. Another transverse perforation was cited by MacKenzie,⁶ in 1884, as follows:

"The patient, Baron de Wassenauer, was 50 years of age and with the exception that he had a sense of fullness after moderate meals, was in perfect health. To relieve this disagreeable feeling he was in the habit of taking a copious draught of an infusion of 'blessed thistle' and ipecacuanha. One day, about 10:30 in the evening, when he had taken no supper but had had rather a hearty dinner, he was bothered by a peculiar sensation in his stomach, and to relieve this he swallowed three tumblersful of his usual infusion. But to no avail. He then tried to excite vomiting by tickling the fauces. In wrenching he suddenly felt a violent pain. He diagnosed his own case by saying that there was 'the bursting of something near the pit of the stomach.' He became prostrate and died in 18 hours. At necropsy it was seen that without any previously existing signs of disease the esophagus had been completely rent across, in a transverse direction."

In our own series we had eight cases of perforation of the esophagus. Seven died, a mortality of 87.5 per cent. Five operations were performed in the eight cases. The patient who survived was one in whom perforation occurred during an esophagoscopy. The cause and outcome of these perforations are shown in Table I.

TABLE I
THE CAUSE AND OUTCOME OF PERFORATIONS OF THE ESOPHAGUS

No of Cases	Cause	Esophagus Perforations			
		Operation	Result		Autopsy
1	Simple ulcer			1	1
1	Diverticulum	1		1	1
3	Ca into trachea	1		3	1
2	Foreign body	2		2	2
1	Trauma (esophagoscopy)	1	1		
8	Totals	5	1	7 (87.5%)	5

ABBREVIATED CASE REPORTS OF PERFORATION OF THE ESOPHAGUS

Perforation of a Simple Ulcer

Case 1—P. H., age 65, had been admitted to the medical service in 1934 for prepyloric ulcer of the stomach, with hemorrhage. He was readmitted in 1936, and on the day of admission had so much distress that he fainted. Voice sounds were diminished at the left base and the abdomen was markedly distended. He died shortly after admission. Autopsy showed a 5 cm longitudinal rent in the lower esophagus which had perforated into the left pleural cavity. An ulcer was seen at the site of the perforation. There were also two ulcers in the stomach proper.

Perforation of Carcinoma of the Esophagus Into the Trachea

Case 2—L. S., female, age 50, with a carcinoma of the esophagus, had had a severe cough after eating followed by bloody expectoration for one week. Roentgenologic examination showed a perforation of the esophagus in the region of the cricoid, which had perforated into the trachea and outlined the trachea and bronchi. The patient died two months later (Fig. 1).

GASTRO-INTESTINAL PERFORATIONS

Case 3—E S, male, age 58, had had difficulty in swallowing of three months' duration, severe cough and expectoration, had lost 50 pounds during three months. He had coughed up swallowed food. Roentgenologic examination showed an obstruction high in the esophagus. The bismuth paste entered the trachea. A Kader gastrostomy was performed but the patient died two months later.

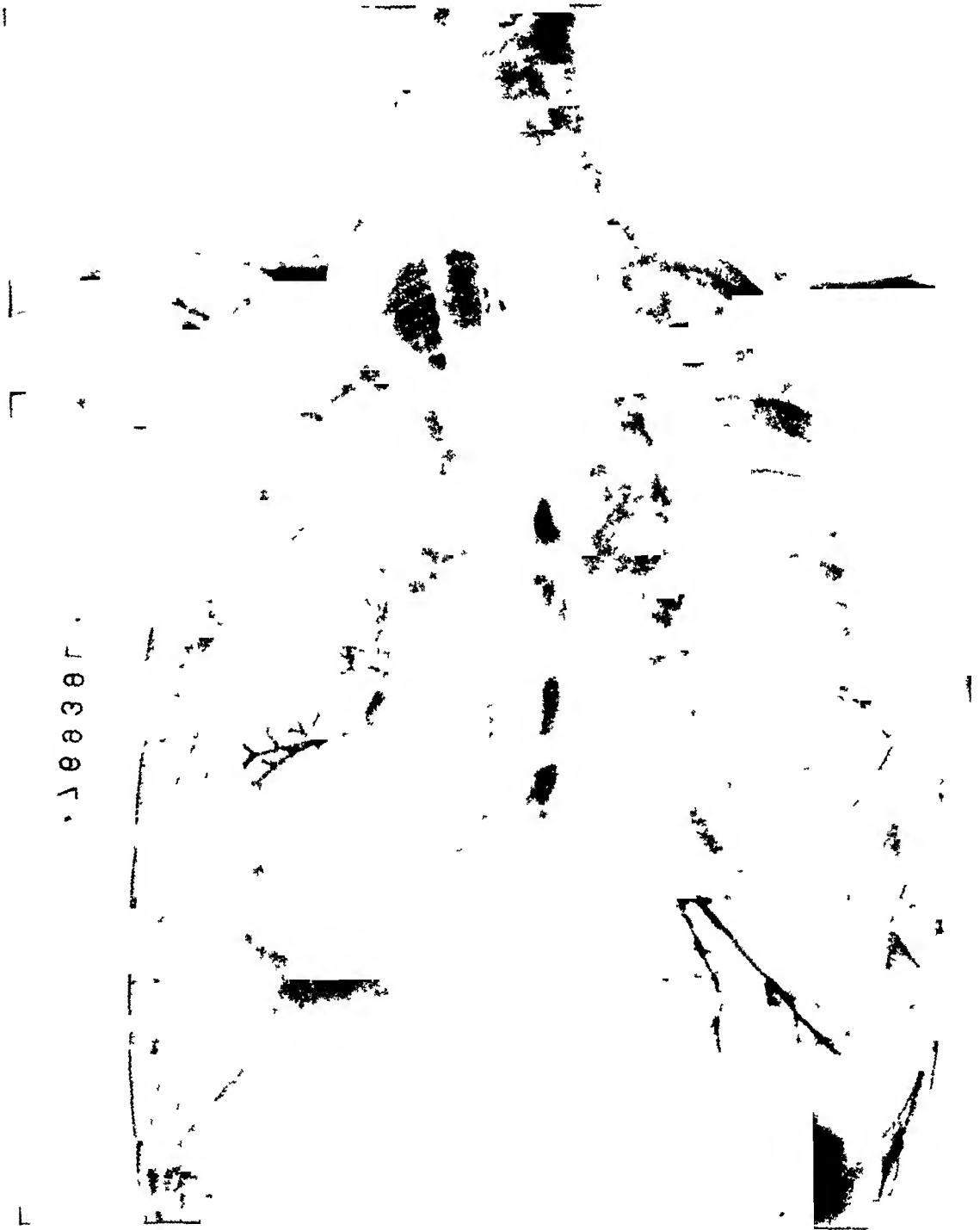


FIG. 1—Case 2, L. S. Roentgenogram of perforation of esophagus into trachea at site of carcinoma. Bronchial tree outlined by barium.

Case 4—T L, female, age 33, had had difficulty in swallowing. Following roentgenologic examination a diagnosis of carcinoma high in the esophagus with pressure onto the trachea was made. The upper esophagus was resected and a gastrostomy was performed in 1936. She died two years later. At autopsy, at the junction of the right

bronchus and trachea a perforation measuring 6 Mm was found. This was present in a necrotic, recurrent tumor, which had taken place at the stump of the esophagus where it had been resected. Microscopic examination showed a recurrent squamous cell carcinoma of the esophagus. Miliary tuberculosis of the lungs and metastases to the mediastinal lymph nodes were also found.

Perforation of an Esophageal Diverticulum

Perforation of a diverticulum is the result of accumulation of food particles which decompose and eventually give rise to symptoms of irritation and serve as a suitable medium for the accumulation of bacteria leading to decomposition of the wall of the diverticulum and finally to perforation.

Case 5—A R, age 37, had had regurgitation of food 30 minutes to three hours after meals. Roentgenologic study showed a small diverticulum of the esophagus at the level of the seventh cervical vertebra. The diverticulum was freed at operation and walled-off with vaselined tampons for secondary resection. Before this could be performed, however, the diverticulum perforated. The patient developed a gangrenous suppuration of the right lung with pneumonia and died on the sixteenth day after operation. Autopsy revealed a perforated diverticulum with mediastinitis and a confluent lung abscess with gangrene of the lung.

Traumatic Perforation by Foreign Body

Case 6—J B, age 71, swallowed a small, hard bone 24 hours before admission, followed by pain in the throat and discomfort on swallowing. Esophagoscopy showed a swelling 0.5 inch wide and 0.5 inch high on the posterior wall of the esophagus one inch below the introitus of the esophagus. On the crest of the swelling a cut was seen into which the point of a forceps could be inserted. This was probed but no foreign body could be felt. Therefore, it was concluded that the bone which had caused the wound must have passed on into the stomach. Swelling developed on both sides of the neck. These swellings were incised widely and drained. Roentgenologic examination showed widening of the mediastinum with pneumonia at the right base of the lung. The patient died the following day. At autopsy, an ulceration and perforation of the esophagus were found, also an acute gangrenous phlegmon of the neck, laryngeal edema, laryngitis and bronchitis, atelectasis of the left lung, lobar pneumonia, and myocardial degeneration. The cause of death was noted as acute laryngeal edema.

Case 7—F M, male, age 27, swallowed an upper denture while asleep, aboard a ship. The ship's surgeon attempted unsuccessfully to remove the denture. Three days later the patient was admitted to Lenox Hill Hospital with swelling on the right side of the neck. Temperature 100.6° F, leukocytes 18,000, polymorphonuclear leukocytes 77 per cent. Roentgenologic examination showed the plate at the level of the clavicle (Fig 2). A futile attempt was made to remove the plate with an esophagoscope. A six-inch incision was then made on the right side of the neck, the vessels of the right lobe of the thyroid were ligated and the lobe turned medially, and the ribbon muscles and omohyoid were divided. The plate could be felt in the hypopharynx. The point seen on the right side in the roentgenogram had perforated the wall of the esophagus. A little exudate, causing a grayish coating, was present in front of the spinal column, with an early abscess cavity, measuring 2.1 inches. Culture from this cavity showed *Micrococcus catarrhalis*, non-hemolytic *Streptococcus*, pneumococcus, and gram-negative *Bacilli*.

It was impossible to dislocate the plate and extract it through the esophagoscope, and so, following a tamponade toward the mediastinum, the opening at the hypopharynx was enlarged and the plate extracted. A Levine tube was placed into the stomach and the wound was left open, lightly packed with iodoform gauze and with a few sutures placed in the skin. Three days later the patient's condition was good and his temperature normal. Two days after this, his condition was still satisfactory, but the following eve-

GASTRO-INTESTINAL PERFORATIONS

ning, at 6 15 P M, profuse hemorrhage suddenly occurred, both from the wound and from the mouth. He lost approximately 1,500 cc of blood. On packing the wound in the neck, the bleeding stopped. Treatment for shock, oxygen and blood transfusion were given. At 7 30 P M all tampons were removed. No bleeding occurred and the tampons were reinserted. At 10 P M, the patient again bled profusely by mouth. The tampons were

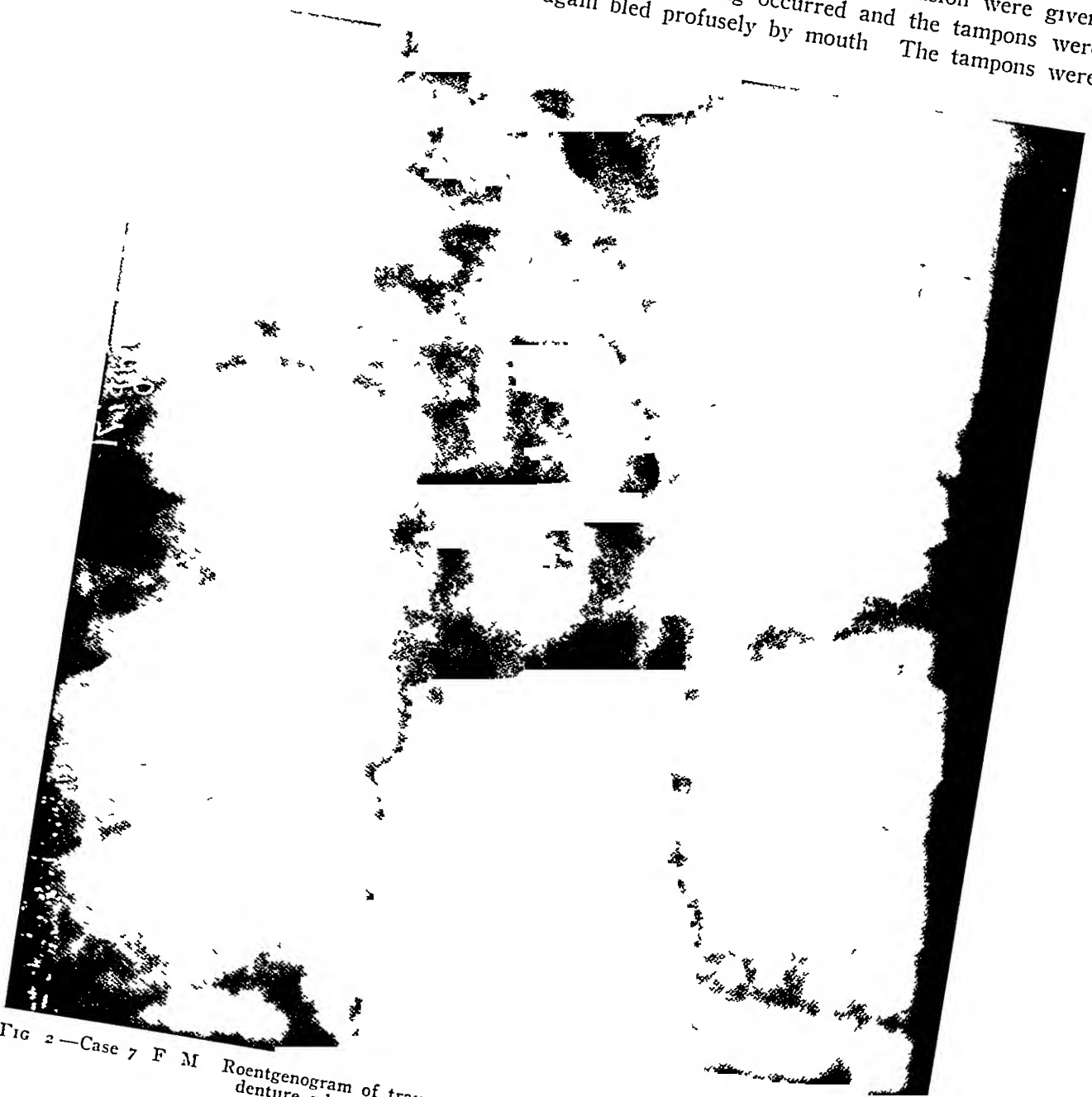


FIG 2—Case 7 F M Roentgenogram of traumatic perforation of esophagus on right side caused by denture which had been swallowed during sleep

removed, but before anything further could be done there was such profuse, frothy bleeding, both from the wound and from the mouth, that the patient expired. At autopsy, interesting findings were discovered. There was an erosion with perforation of the right common carotid artery, elliptic in shape, measuring 0.5 x 1.5 cm. There was also an erosion, with perforation of the esophagus into the trachea, at the seventh cartilaginous ring. The perforation into the trachea was 1 cm from that found in the carotid artery. This explained the hemorrhage, both from the mouth and from the wound.

Traumatic Perforation During Esophagoscopy

Case 8—M S, female, age 59, was admitted to the Lenox Hill Hospital, on account of difficulty in swallowing and regurgitation of food. Roentgenologic examination showed an obstruction at the cardia. Esophagoscopy was performed at 9:30 A. M. under avertin anesthesia. An 11 Mm tube was passed into the stomach easily. A longer, smaller tube was then passed a short distance, whereupon blood was noticed in the tube. Immediate use of an esophageal speculum showed a short split in the mucous membrane on the posterior wall of the esophagus. The patient became very uncomfortable. The neck was tender with crepitation and severe pain on swallowing. Immediate operation advised.

Operation—Under local anesthesia, an incision was made along the sternomastoid muscle and air was noted in the tissues, especially in the deeper part of the neck. The thyroid was drawn to the left after liberating the lower pole. On freeing the esophagus upward, a cavity was entered containing purulent, bloody material which was removed by suction. Cultures were taken. The cavity descended downward into the mediastinum on the right side of, and behind, the esophagus. There was a purulent-like deposit lining it, and in rotating the esophagus over to the left in order to expose the posterior surface, a large slit-like opening more than one-half inch in length was exposed. The edges were everted. The slit was closed by means of three chromic sutures. The wound was drained and iodoform gauze tampons placed down into the mediastinum, to the lowest margin of the cavity. Apparently the cavity was walled-off toward the deeper parts of the mediastinum. Another tampon was placed upward but not against the suture line. Superficial tampons saturated with hexylresorcinol were placed in the wound, and the lower end of the bed elevated.

Postoperative Course—The following day the patient was doing nicely. Two days later the superficial tampon was removed and replaced. The following day, a Levine tube was inserted for feeding purposes. There was evidence of slight leakage at the side of the neck. On the seventh day, the deep mediastinal tampon was gradually removed. There was a profuse foul discharge. On the ninth day, the last tampon was removed. On the sixteenth day, feedings were started by mouth, with no evidence of leakage. Two days later, the Levine tube was removed and all feedings were given by mouth. The patient was discharged one week later with the wound healed, and perfectly well. The culture from the abscess cavity showed pneumococcus, *Micrococcus catarrhalis*, *Staphylococcus albus*, and diphtheroid *Bacilli*.

DISCUSSION—Analysis of these eight cases shows that a perforation of the esophagus is always a very serious injury, with an inevitably high mortality. The presence of mouth organisms in the upper esophagus, and secondary phlegmonous infection of the neck along the fascial planes, followed by mediastinitis is a very grave complication. The only procedure that can save these patients is early diagnosis, early operation, wide incisions, and tamponade drainage with the introduction of antiseptics into the wound.

GASTRIC AND DUODENAL ULCER PERFORATIONS—Many interesting cases of perforation have been reported in the early literature. One of the earliest is that reported by Crollius, in 1613. A Bohemian peasant concealed a knife in his mouth, thinking no one would suspect that he possessed it. While excited, he let the knife slip into his stomach. It subsequently penetrated through to the skin and the man recovered. Somewhat similar cases are those of a young woman, age 22, who, in delirium from typhoid fever, swallowed two iron forks which were subsequently expelled through an abdominal abscess,⁷ and a French woman, age 35, who, with suicidal intent, swallowed a four-pronged

fork which was removed four years later from her thigh, after two years of intense pain in that region.⁸

In this peculiarly interesting group of cases should be included one described by Hashimoto, former surgeon general of the Imperial Japanese Army, another described by Garcia,⁹ and still another mentioned by Houston.¹⁰

Hashimoto's case was a woman, age 49, who was in the habit of inducing vomiting by irritating her fauces and pharynx with a Japanese tooth brush, a wooden instrument six or seven inches long with bristles at the end. Then, one day, she swallowed the brush accidentally. Eleven months later there appeared in the epigastric region a fluctuating swelling which finally burst and from it extruded the end of the brush. After vainly attempting to extract it, the attending physician contented himself with cutting off the projecting portion. The opening subsequently healed. Thirteen years later pain and swelling returned. On admission to the hospital, October, 1888, two fistulous openings were seen in the epigastric region and the foreign body was located by probing. Six weeks later the patient was anesthetized, one of the openings was enlarged and the brush was extracted. In another five weeks the openings had healed and the patient was restored to health.

Garcia's patient was a man who swallowed a swab, ten inches long, which he had used for cleansing his fauces. On the sixteenth day after this, an abscess formed on the left side below the nipple and from it was discharged a large quantity of pus and blood. In another four days the end of the stick protruded. The stick was withdrawn by traction. The wound healed within seven weeks.

Houston mentions a maniac who swallowed a rusty spoon, 11 inches long. Fatal peritonitis ensued and the spoon was found impacted at the duodenojejunal junction. Hinder¹¹ reports a rupture of the duodenum by a violent kick.

Spontaneous perforations of the stomach have occurred in a number of individuals. Wunschheim¹² reported the spontaneous rupture of the stomach in a man who vomited and could not empty the stomach on account of an esophageal carcinoma ten inches from the teeth. Collins¹³ described a spontaneous rupture of the stomach in a woman, age 74, the subject of lateral curvature of the spine, who had frequent attacks of indigestion with tympanitis. On the day of death there was considerable distention, and a gentle purgative and antispasmodic were administered. Just before death, a sudden explosive sound was heard, followed by collapse. A necropsy showed a rupture, two inches long situated two inches from the pyloric end of the stomach. Lallemand¹⁴ also mentions a rupture of the stomach by the act of vomiting. The patient was a woman who had suffered with indigestion for five or six months but had been relieved by a strict diet. After indulging her appetite to a greater extent than usual, she experienced nausea and made violent but ineffectual efforts to vomit. While suffering great agony, she experienced a sensation as if something were tearing in the lower part of her abdomen. Then she became unconscious and died that night. Postmortem examination showed that the anterior and middle parts of her stomach had been torn, obliquely, to the

extent of five inches, the tear extending from the lesser toward the greater curvature. The edges were thin and irregular and presented no evidences of disease.

In our own series, there were 81 perforations of gastric ulcer and 23 of duodenal ulcer. It may be purely a coincidence that the incidence of gastric ulcer perforations was greater during the years of panic and depression than during the period of prosperity (Chart 2). Let us hope, if this be a correct observation. That the lower number of cases in the 1937-1938 period points to the beginning of new prosperity. In other words, worry and deprivation, with increased nervousness and, therefore, increased smoking and drinking, may have caused an increase in the occurrence of gastric ulcer. The incidence of perforation in duodenal ulcers has remained at about the same low level.

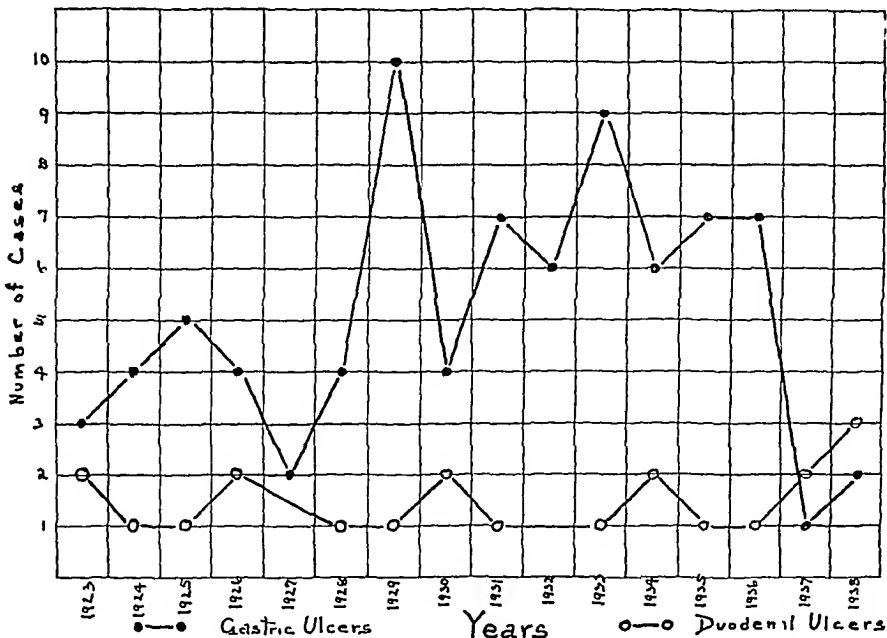


CHART 2—Showing the incidence of gastric ulcer during the period from 1923 to 1938

Sex Incidence—There were 76 males in the series of 81 gastric ulcer perforations, and 22 males among 23 duodenal ulcer perforations. In the small intestine, 15 perforations occurred in males in 16 cases. In the large intestine, the incidence was about evenly divided between males and females (Table II).

TABLE II

SEX INCIDENCE IN GASTRO-INTESTINAL PERFORATIONS

	Male	Female
Gastric ulcers	76	5
Duodenal ulcers	22	1
Esophagus	5	3
Traumatic gastric perforation	0	1
Small intestines	15	1
Carcinoma perforations	2	2
Colon perforations	4	2
Diverticulitis perforations	6	6

GASTRO-INTESTINAL PERFORATIONS

Age Distribution—Perforation of gastric or duodenal ulcers rarely occurred in the very young or the very old. Our youngest case was age 16, the eldest age 75. The average age for gastric ulcers was 42.4 years, for duodenal ulcers 44.1 years. The average age of perforations of the colon, due to inflammatory lesions, was 30 years, whereas, in diverticulitis of the sigmoid with perforation, the average age was 54.5 years. The average age for all perforations is shown in Chart 3.

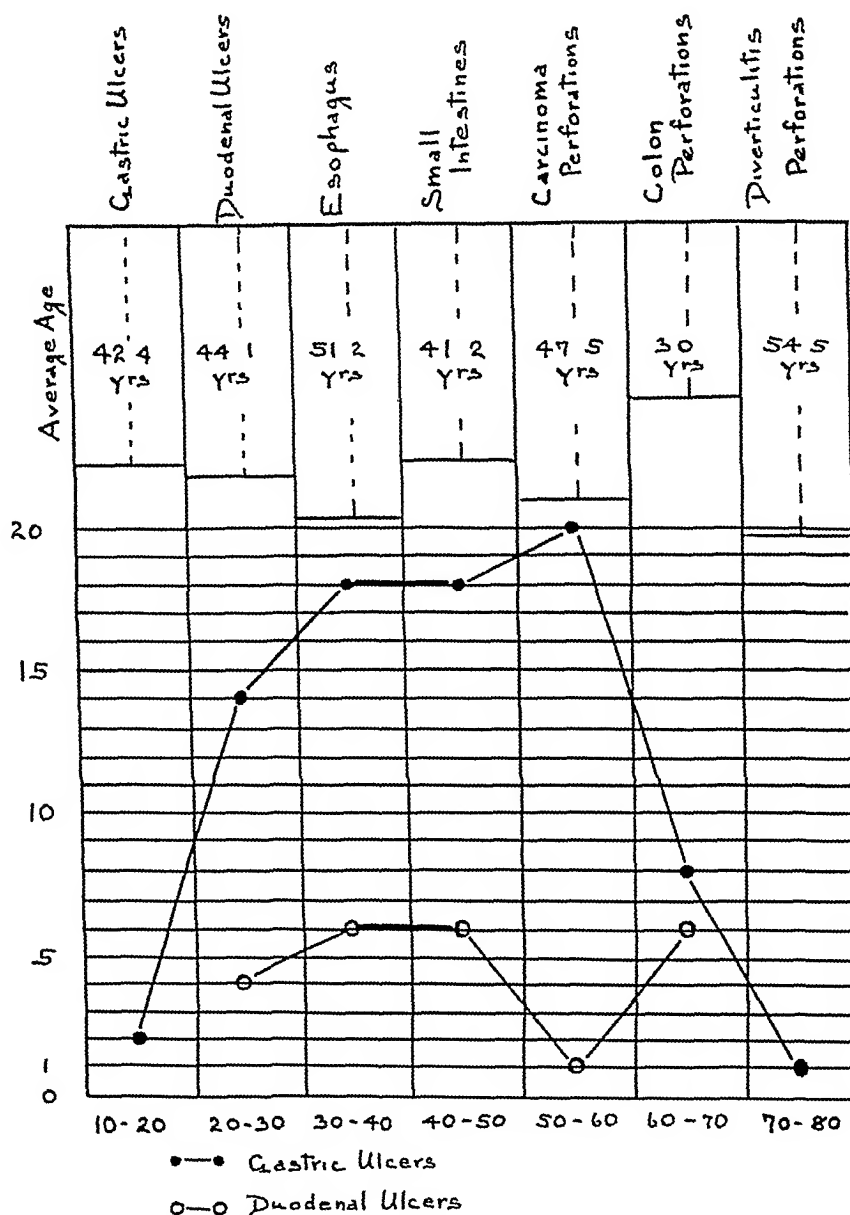


CHART 3—Showing, graphically, the age distribution of all perforations

Past History—In 17 of the 81 cases (21 per cent) of perforated gastric ulcer and in two of the 23 cases (8.6 per cent) of duodenal ulcer perforation, the rupture occurred without a previous ulcer history. The mortality was slightly higher in gastric ulcer perforations with no previous ulcer history than in those with such a history. On the other hand, previous symptoms were the rule in cases of duodenal ulcer perforation (Table III).

TABLE III

PATIENTS WITH PAST HISTORY OF ULCER

Gastric Ulcer	Duodenal Ulcer
Total, 81 cases	Total, 23 cases
No previous symptoms 17 or 21% 5 died (29 4%)	No previous symptoms 2 or 8 6% 1 died (50%)
Previous symptoms 64 (79%)	Previous symptoms 21 or 91 4%
Average years 3 3, 17 died (26 5%)	Average years 3 7 died (33%)
Average years 3 8	Average years 1 5

Time of Hospitalization—From the economic standpoint, perforation of a gastric or duodenal ulcer is not as serious a catastrophe as perforation of the lower intestinal tract. The average stay in the hospital in the gastric ulcer cases was 25 4 days and in the duodenal cases 19 5 days. The gastric ulcer patients who died after operation lived an average of 4 5 days, ranging from one to two days after operation up to 11 days. In the duodenal ulcer cases, those who died lived an average of 7 2 days, that is, longer than the gastric ulcer cases. The majority died the first day, but some lived to the sixteenth and nineteenth days postoperatively (Chart 4)

4 5 days	25 4 days
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Gastric Ulcer
Average Stay in Hospital

Mortality Cases

Average Stay 4 5 Days

1st day	4 cases
2nd day	5 cases
3rd day	2 cases
4th day	2 cases
6th day	3 cases
7th day	2 cases
8th day	1 case
9th day	1 case
11th day	2 cases

7 2 days	19 5 days
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Duodenal Ulcer
Average Stay in Hospital

Mortality Cases

Average Stay 7 2 Days

1st day	4 cases
7th day	1 case
12th day	1 case
16th day	1 case
19th day	1 case

CHART 4—Showing the length of hospitalization of gastric and duodenal ulcer cases

Time Between Perforation and Admission to Hospital—The average lapse of time between admission to the hospital and perforation, in our successful cases, was 4 4 hours in the gastric ulcer group, and 12 8 hours in the duodenal group. The average time in the fatal cases was 24 4 hours in the gastric and 29 6 hours in the duodenal ulcer group. The average time

GASTRO-INTESTINAL PERFORATIONS

in all cases was 8 8 hours in the gastric ulcer group, and 17 9 hours in the duodenal ulcer patients (Chart 5)

	Gastric Ulcers	Duodenal Ulcers
Successful Cases	4 4 hours	12 8 hours
Fatal Cases	24 4 hours	29 6 hours
Average All Cases	8 8 hours	17 9 hours

CHART 5 —Showing the lapse of time between admission and perforation



FIG 3 —Roentgenogram of perforation of gastric ulcer showing obliteration of liver dulness, with air under both diaphragms

Eliason and Ebeling¹⁵ state that if operation is performed within six hours, the mortality is 7.5 per cent, from six to 12 hours, 32.9 per cent, from 12 to 24 hours, 35.4 per cent, and from 24 to 48 hours, 67.5 per cent. The shortest time element in our series was 20 minutes from the onset of acute symptoms, the longest, a patient in whom perforation occurred five days before admission. The latter case died. Mortality is in direct ratio to the lapsed time between perforation and operation. As stated at the outset, "The



FIG. 4.—Roentgenogram of perforation of gastric ulcer showing air and fluid under right diaphragm.

sun must never use or set without an attempt at the relief of the pathology."

Physical Signs—The most common physical sign of gastric or duodenal perforation is board-like rigidity of the abdomen, extending from the upper abdomen, downward, depending on the amount of fluid that has escaped into the peritoneal cavity, and that which has run down the lumbar gutters into the pelvis. Fluid may also pass upward to the undersurface of the diaphragm and may be identified by roentgenologic examination. Rigidity is rarely absent, but may be moderate or slight.

Liver dulness is another important sign. Its absence indicates a condition of pneumoperitoneum, or an air between the liver and the diaphragm, and is indicative of perforation of a hollow organ, usually the stomach or duodenum, more rarely the small intestine. Liver dulness was noted as "absent" in 28 of our gastric ulcer perforations and in four of our duodenal ulcer perforations. In 48 gastric and 15 duodenal ulcer cases, no mention of this finding was made in the physical examination, probably indicating that liver dulness was present (Table IV).

TABLE IV
THE RELATIVE FREQUENCY OF VARIOUS PHYSICAL SIGNS

	Gastric Ulcers	Duodenal Ulcers
Rigidity		
Marked	69	18
Moderate	5	2
Slight	5	2
None	1	1
Mass in abdomen	1	
Liver dulness		
Absent	28	4
Present	5	4
Not indicated but probably present	48	15

Clinical Findings—When perforation occurs the pulse may become rapid and thready, but by the time the patient reaches the hospital the temperature averages 99.2° F, pulse 82, in patients with gastric ulcer, and 100.2° F, pulse 98, in those with duodenal ulcer. A temperature of 102° or 103° F, and a pulse rate of 110 to 120 on admission, are indicative of peritonitis and predicate a grave prognosis.

The average leukocyte count on admission in our series was 14,900 in the gastric ulcer cases and 13,300 in patients with duodenal ulcer, an average of 85 and 84 per cent polymorphonuclear leukocytes, respectively. In many instances the counts were much higher, but in the very critical cases, the polymorphonuclear leukocytes were low, indicating poor resistance. In every such instance the patient died (Table V).

TABLE V
CLINICAL FINDINGS ON ADMISSION

Average	Gastric Ulcers	Duodenal Ulcers
White blood cells	14,900	13,300
Polymorphonuclear leukocytes	85%	84%
Temperature	99.2°	100.2°
Pulse	82	98

Preoperative Diagnosis—Ninety-two point six per cent of all cases of perforated gastric ulcer were diagnosed correctly preoperatively. The remainder were diagnosed as acute appendicitis. In these, the appendix was found to

be normal at operation, with evidence present of local peritonitis and free fluid due to a perforated gastric ulcer. In the duodenal ulcer cases, intestinal obstruction and gastric ulcer perforations were erroneously diagnosed in three cases (Table VI).

TABLE VI
PREOPERATIVE DIAGNOSES

Gastric Ulcers		Duodenal Ulcers	
Perforation	75 or 92.6%	Intestinal obstruction	1
Acute appendicitis	6 or 7.4%	Gastric ulcer	2
		Perforated duodenal ulcer	17

Roentgenologic Examination—In cases of perforation of the stomach and duodenum, failure to demonstrate gas by roentgenologic examination may occur in more than 25 per cent of cases. The use and results of roentgenologic examination in our gastric ulcer series are shown in Table VII. One case showed deformity of the pylorus, and at operation, an ulcer of the pylorus was found which had perforated but had become freshly sealed. In another case, roentgenologic examination showed an hour-glass stomach, and at operation a perforated ulcer on the anterior wall of the stomach was found adherent to the anterior abdominal wall. Three cases showed pyloric stenosis with retention and all three were operated upon, with the following sequence of events. One presented an ulcer which perforated during handling at the time of operation, another perforated two weeks after the roentgenologic examination, and the third, three months thereafter.

TABLE VII
INTERPRETATIONS OF THE ROENTGENOLOGIC EXAMINATION OF
PERFORATED GASTRIC ULCERS

26 cases examined before operation	(32%)
18 plain films	
Air under diaphragm	10 cases (55.5%)
Air and fluid under diaphragm	3 cases (16.6%)
Negative findings	5 cases (27.7%)
8 with barium meal	
Perforation during examination	3 cases
6 hours after meal	
10 hours after meal	
24 hours after meal	
Deformity of the pylorus (sealed perforation found)	1 case
Hour-glass stomach (perforation sealed anterior abdominal wall)	1 case
Pyloric stenosis	3 cases
(1) Ulcer perforated during operation	
(2) Ulcer perforated two weeks later	
(3) Ulcer perforated three months later	

In the duodenal ulcer series, four of 23 (17.4 per cent) were examined roentgenologically (Table VIII)

TABLE VIII
INTERPRETATIONS OF THE ROENTGENOLOGIC EXAMINATION
OF PERFORATED DUODENAL ULCERS

Cases examined	4 out of 23, or 17.4%
Plain films	2 cases
Air under diaphragm	1 case
Negative	1 case
With barium meal	2 cases
Duodenal ulcer	2 cases

Operative Procedures—Fifty-eight of our 81 gastric ulcer perforations had simple closure of the perforation with 24.1 per cent mortality, four had simple closure of the ulcer plus appendectomy, with 25 per cent mortality, 13 had primary closure plus gastro-enterostomy, with 30.7 per cent mortality. Two patients who had primary gastric resection at the time of perforation survived. Two cases were drained, with 50 per cent mortality. One of these patients had a large, bilateral subdiaphragmatic abscess with air and pus under the diaphragm. No distinct perforation could be identified at operation but later, roentgenologic examination showed the presence of a perforating ulcer. This patient survived. The other patient was a late case with a perforation near the cardia that could not be properly sutured. In spite of drainage, the patient died.* Two cases were so ill that operation was contraindicated and both died. The types of operation performed and the mortality of each are shown in Table IX.

TABLE IX
SUMMARY OF RESULTS OF OPERATIONS FOR PERFORATED GASTRIC ULCERS

Type of Operation	Cases	Deaths	Mortality Per Cent
Closure	58	14	24.1
Closure and appendectomy	4	1	25
Closure and gastro-enterostomy	13	4	30.7
Gastric resection	2	0	0
Drainage only	2	1	50
No operation (too ill)	2	2	
Totals	81	22	27.1

In the duodenal ulcer cases, practically the same statistics prevailed, as shown by Table X. Sixteen had simple closure, with four deaths, or 25 per cent mortality; three had closure plus immediate gastro-enterostomy, with 33 per cent mortality, and one had closure of the perforation plus stretching of a seemingly closed gastro-enterostomy that had been performed two years previously for duodenal ulcer. This second procedure was followed by recovery and the patient has remained well for 12 years. Primary resection was

* Robert T. Morris⁴⁸ reports a case of unusually large perforation at the site of an old gastric ulcer. He did not close the perforation but placed a large wick drain down to the opening. The patient made a good recovery.

performed in one case but the patient succumbed to an apparent cardiac failure during operation. Two cases were not operated upon because they were too ill. The total average mortality in the operated duodenal ulcer cases was 34.7 per cent.

TABLE X

SUMMARY OF RESULTS OF OPERATIONS FOR PERFORATED DUODENAL ULCERS

Type of Operation	Cases	Deaths	Mortality Per Cent
Closure	16	4	25
Closure and gastro enterostomy	3	1	33
Closure and stretching of a previous gastro-enterostomy	1	0	0
Resection	1	1	100
No operation (too ill)	2	2	
Totals	23	8	34.7

If we now compare our own statistics with those of other authors, here and abroad, as shown in Table XI, the outstanding fact is that the average mortality in a large series of cases, that is more than 50 cases, is between 20 and 25 per cent. A few reports are remarkable for their low mortality rate.

TABLE XI

COMPARATIVE OPERATIVE MORTALITY AND TYPE OF OPERATION

	Pres- ent Series	Guth- rie ¹⁶	Mat- tingly ¹⁷	Smith ¹⁸	Sear by ¹⁹	Gil- mour and Saint ²⁰	Wood all ¹	Gra- ham ⁴⁹	But- ler ³	Bren- ner ²⁴	Til- ton ⁴⁶	Mc Creery ⁴⁷
No. of cases	104	42	91	41	33	64	36	60	47	27	52	170
Per cent mortality	27.5	16.6	14.2	6.1	6.1	4.7	13.9	3.3	6.3	3.7	1.9	20.5
Simple closure	78	42	90	39	33	63	31	60*		27	52	
Closure and gastro- enterostomy	16		1	2		1	1	16				22
Secondary gastro- enterostomy	5	3	4				8					3
Pyloroplasty									47			
	U S A 1921- 1933 44 Sources ⁵	22 For- eign Clin- ics 1921- 1932 Indi- vidual ²⁵	22 For- eign Clin- ics 1921- 1932 Com- bined		Sha- wan ²⁶	Graves Schmie- den Clinic Frank- furt	Rhodes and Col- lins ⁷	James ⁸	Eli- son and Ebel- ling ¹⁵	Black ⁹		
No. of Cases		3121	5061		227	144	155	75	74	50		
Per cent mortality		25.9	22.6	23.9	24.2	26	25	24	47.2	8		

Butler²³ believes that simple closure should be undertaken by all except the most experienced surgeons, and that, where the elapsed time is under six hours and the ulcer is duodenal and chronic, with moderate induration and deformity, excision of the ulcer should be performed, continuing the incision through the pyloric ring and suturing the wound transversely. If the ulcer be callous, the deformity great, and the time under six hours, a posterior gastro-enterostomy might well be performed. In gastric perforations, only a

* This simple closure was by free or pedunculated fat graft tied over the perforation.

simple closure with possible cauterization or excision of the ulcer margin should be performed regardless of the time of perforation. Woodall²¹ feels that any additional surgery, such as gastro-enterostomy, excision of the ulcer, or pyloroplasty, performed at the time of primary closure of the perforation, adds a definite risk and can be justified only by the prospect of unquestioned benefits accruing therefrom.

It is the consensus of opinion, in which our experience causes us to concur, that simple closure is the safest procedure. Secondary gastro-enterostomy is rarely required, and is safer as a secondary procedure when definitely indicated.

We used general anesthesia when operating upon 64 gastric and 14 duodenal ulcer cases. Spinal anesthesia was used nine times in gastric and four times in duodenal ulcers. It was necessary in a few instances to supplement the spinal anesthesia with a general anesthetic. Local anesthesia was used twice in each group (Table XII).

TABLE XII
ANESTHESIA

	Gastric Ulcers	Duodenal Ulcers
General	64	14
Local	2	2
Spinal	9	4
General and spinal	4	1
	79	21

Apparently, in early cases it does not make much difference whether patients are drained or not. We agree with Woodall²¹ that drainage is indicated, and is of value only in the grave, late cases. In our series, drains were used as follows:

TABLE XIII
DRAINS

	Gastric Ulcers	Duodenal Ulcers
Cases	79	21
Drained	28 (35.4%)	7 (33%)
Died	14 (50%)	5 (71.4%)

Pathology—The peritoneal fluid was cultured in 15 gastric ulcer perforations and was sterile in nine (60 per cent). In six instances, the reports of the culture were positive: (1) *Micrococcus pharyngococcus siccus*, (2) *Staphylococcus albus* and *vidans*, (3) *pneumococcus*, Type 3, (4) *Staphylococcus albus*, (5) *bacillus diphtheroid*, and (6) short-strain *Streptococcus* gram-negative Diplococci and gram-negative Bacilli. The only positive culture in the duodenal group was a *Staphylococcus albus*.

The average, approximate, size of perforation in the gastric group was 5.8 Mm., in the duodenal group, 7.2 Mm. The smallest pin-point perforations were approximately 2 Mm. in diameter. The largest, of a gastric ulcer, was 18 Mm., and this patient died. Another patient, with a 20 Mm. perforated

duodenal ulcer, recovered. Apparently the size of a perforation had no direct relation to prognosis.

The closer the perforation was to the pylorus the better the prognosis, the nearer to the cardia, the worse. The great majority of gastric ulcers occurred close to the pylorus. The majority of perforations of the duodenum were in the first portion. Fourteen were in this region, five in the second portion, one on the posterior wall, and in three instances the location was not stated.

The pathologic findings are summarized in Table XIV.

TABLE XIV

SUMMARY OF THE PATHOLOGY OF THE PERFORATED ULCERS

Culture	Gastric Ulcers	Duodenal Ulcers
Reported	15	3
Sterile	9	2
Positive	6	1
Size of perforation (approximate)		
Average	5.8 Mm	7.2 Mm
Smallest	2 Mm	2 Mm
Largest	18 Mm (died)	20 Mm (cured)
Location of perforation		
At pylorus	55	
1"-2" from pylorus, lesser curvature	17	
1" or more from pylorus		
Anterior wall, greater curvature	3	
Posterior wall, sealed	1	
Near cardia	1	
No perforation seen	1	
1st portion		14
2nd portion		5
Posterior wall		1
Not noted		3

Pre- and Postoperative Complications—The pre- and postoperative complications of the gastric ulcer cases are shown in Tables XV and XVI.

TABLE XV

COMPLICATIONS IN ADDITION TO PERFORATION OF GASTRIC ULCER

No of Cases	Preoperative	Postoperative	Result
1	Mitral stenosis and insufficiency	Pneumonia	Death
5	General peritonitis	Bronchopneumonia	5 deaths
1	Hyperthyroidism	Parotitis	Cured
1	Operation for perforated gastric ulcer one year before		Cured

In Woodall's series²¹ of 26 traced cases, ten were reoperated upon subsequently, two were for second perforations occurring four and 12 months after the original perforation, the remaining eight were for obstruction occurring six weeks to 14 years after the primary perforation. Five of the eight obstructions developed within one year of the original operation, two within three years, and one within 14 years.

In our duodenal group, there were 12 cases with pre- and postoperative

GASTRO-INTESTINAL PERFORATIONS

TABLE XVI

POSTOPERATIVE COMPLICATIONS OF PERFORATIONS OF GASTRIC ULCER

Operation	No of Cases	Complication	Result	
			Cured	Died
Closure	3	Pyloric stenosis, all 3	3	
Closure	2	Parotitis, both	2	
Closure	2	Wound disruption, pneumonia, both	2	
Closure	1	Phlebitis femoral vein	1	
Closure	1	Pleurisy	1	
Closure	1	Subphrenic abscess, drained	1	
Closure	3	Wound infection, all 3	3	
Closure	1	Atelectasis left lung	1	
Closure	1	Atelectasis right lung		1
Closure	2	Bilateral pneumonia, both		2
Closure	7	Peritonitis, general, all 7		7
Closure	1	Subphrenic abscess, peritonitis		1
Closure and appendicectomy	1	Bronchopneumonia	1	
Closure and appendicectomy	1	Peritonitis		1
Closure and gastro-enterostomy	1	Wound infection	1	
Closure and gastro-enterostomy	1	Wound disruption	1	
Closure and gastro-enterostomy	1	Pneumonia		1
Closure and gastro-enterostomy	1	Gastric hemorrhage		1
Drainage	1	Sepsis		1

complications One case had had a cholecystectomy and an appendicectomy one year previously Two patients had positive Wassermann reactions and recovered without complication Two had postoperative wound infections,

TABLE XVII

PREOPERATIVE AND POSTOPERATIVE COMPLICATIONS, BESIDES PERFORATION, OF DUODENAL ULCERS

Operation	No of Cases	Preoperative Complication	Postoperative Complication	Result	
				Cured	Died
Closure	2		Wound infection, both	2	
Closure	1	Cholecystectomy and appendicectomy 1 year before		1	
Closure	2	Syphilis, both		2	
Closure	1		Duodenal hemorrhage	1	
Closure	2	Peritonitis	Pneumonia		2
Closure	1	Ileocecal resection for Ca 9 years before	Peritonitis		1
Closure	1		Subphrenic abscess, operation		1
Closure and gast-ent	1		Lung abscess		1
Closure and Stretching of gast-ent	1	Gastro-enterostomy two years before		1	

and one had a duodenal hemorrhage. All of these cases were operated upon with simple closure of the perforation. The complete analysis is shown in Table XVII.

Readmissions—Fifteen of the cases of gastric ulcer perforations were readmitted to the hospital after the first operation, two were readmitted twice, dying at the time of second readmission. Five duodenal ulcer cases were readmitted a second time. A complete analysis of the readmissions is shown in Table XVIII.

TABLE XVIII

ANALYSIS OF INSTANCES OF READMISSION FOLLOWING OPERATION FOR
PERFORATED GASTRIC ULCER

Cause	Previous Operation	Time Elapsed	Treatment	Immediate Result
Bleeding ulcer	Closure and gastro-enterostomy	9 yrs	Gastric resection	Cured
Pain, vomiting and hemorrhage	Closure	2 yrs	Gastric resection	Cured
Marginal ulcer, vomiting, hemorrhage	Closure and gastro-enterostomy	1 yr	Gastric resection	Cured
Pneumonia	Closure, secondary gastro-enterostomy	7 yrs		Died
Ulcer symptoms, vomiting	Closure and appendectomy	1 yr	Duodenal tube feeding	Cured. Operated on 2 yrs later for ulcer, elsewhere
Ulcer symptoms, vomiting, duodenal ulcer	Closure	5 yrs	Operation advised, refused	Unimproved
Ulcer symptoms, hemorrhage	Closure	{ 5 yrs 6 mos }	Sippy diet	{ Improved Died }
Pain and vomiting				
Ulcer symptoms, Pain and vomiting	Closure	{ 5 yrs 7 mos }	Sippy diet	{ Improved Died }
Pain and vomiting				
Peritonitis (cause unknown)	Closure and gastro-enterostomy	7 mos	Drainage	Died
Pyloric stenosis	Closure	2 mos	Gastro-enterostomy	Cured
Pyloric stenosis	Closure	7 mos	Gastro-enterostomy	Cured
Pyloric stenosis	Closure	9 mos	Gastro-enterostomy	Cured
Duo ulcer, x-ray evidence	Closure	1 ½ yrs	Gastro-enterostomy	Cured
Perforation, ulcer	Closure	4 yrs	Closure	Cured
Pain, hemorrhage, x-ray evidence of retention, regional ileitis, colitis	Closure	2 yrs	Sippy diet	Improved

GASTRO-INTESTINAL PERFORATIONS

READMISSION DUODENAL ULCER CASES

Cause	Previous Operation	Time Elapsed	Treatment	Immediate Result
Pyloric stenosis	Closure	1 yr	Gastro-enterostomy	Cured
Pyloric stenosis	Closure	7 yrs	Gastro-enterostomy	Cured
Perf ulcer with peritonitis, 6 days	Closure	22 mos		Died
Duo ulcer, symptoms	Closure	4 mos	Medical treatment	Improved
Ca tongue, tonsils, nodes	Closure	10 yrs	Gastrostomy	Died

Follow-Up of Gastric Ulcer Perforations—We have classified the follow-up (Table XIX) according to the type of operation performed, namely, simple closure, closure plus gastro-enterostomy, gastric resection and drainage

Simple Closure—Of 62 cases that had simple closure, 15 are known to be dead, 47 alive. Of these 47, 24 (51 per cent) have been followed to date, an average of five years. Fifteen were followed for six months to seven years but were finally lost to follow-up (average time followed, three years). Three cases died later, and of five cases we have no follow-up at all. Of the 24 followed to date, 21 (87.5 per cent) are well, three have symptoms but are well if they maintain a diet. Of the remaining 21, one was recently operated upon for cholelithiasis, but has had no ulcer symptoms, one had a cauterization and pyloroplasty elsewhere, four had a secondary gastro-enterostomy. Of the 15 cases lost to follow-up, one was known not to be well after five years, another had a secondary operation (probably gastro-enterostomy) in Sweden, ten months after the first procedure, and was well three years later, and another case had signs of stenosis five years later, for which gastro-enterostomy was advised.

TABLE XIX

FOLLOW-UP RESULTS ON CASES OPERATED UPON FOR PERFORATED GASTRIC ULCERS

No. of cases followed to date	24
Well	21 (87.5%)
Ulcer symptoms	3

Analysis According to Procedure

Procedure	No. of Cases	Dead	Alive	Followed to Date	Per Cent	Time Followed	Aver Time	Followed But Lost	Time Followed	Aver Time	Died Later	No Record
Closure	62	15	47	24	51	6 mos to 13 yrs	5 yrs	15	6 mos to 7 yrs	3 yrs	3	5
Closure plus gastro-enterostomy	13	4	9	0				6	1 to 9 yrs	4 yrs	2	1
Resection	2		2					1	1 yr			1
Drainage	2	1	1					1	3 mos			

Primary Closure Plus Gastro-Enterostomy—Of 13 cases, four are known to be dead. None of the remaining nine have been followed to date, but six were followed from one to nine years, and were well when last seen.

Primary Resection—One case was followed a year and was well at that time. The other case was lost to follow-up.

Primary Drainage—One case was followed for three months and then lost. The other patient died.

Follow-Up of Duodenal Ulcer Perforations—Simple closure was performed in 17 cases, of whom four are dead. Six have been followed to date (46.1 per cent). Of these, four are well and two have ulcer symptoms. Another three cases were followed from one month to two years. Three died later, and one case was not followed at all. Of three cases who had primary closure plus gastro-enterostomy, one died, one was followed for ten years, and was lost to follow-up but was well at that time, and the third was not followed (Table XX).

TABLE XX

FOLLOW-UP RESULTS ON CASES OPERATED UPON
FOR PERFORATED DUODENAL ULCERS

No. of cases followed to date	6
Well	4 (66.6%)
Ulcer symptoms	2

Analysis According to Procedure

Procedure	No. of Cases	Dead	Alive	Followed to Date	Per Cent	Time Followed	Aver Time	Followed But Lost	Time Followed	Aver Time	Died Later	No Record
Closure	17	4	13	6	46.1	4 mos to 12 yrs	5½ yrs	3	1 mo to 2 yrs	1 yr	3	1
Closure plus gastro enterostomy	3	1	2					1	10 yrs			1
Resection	1	1										

Analysis of Immediate Operative and Late Mortality—The analysis of 22 deaths following operation in the gastric ulcer series is seen in Table XXI. In seven of the 22 deaths, autopsy was performed and the findings are recorded. An analysis of the eight operative deaths in the duodenal series is detailed in Table XXII. The combined analysis is presented in Table XXIII.

Late Mortality—In the gastric ulcer series, there were five late deaths. One patient had had closure and a gastro-enterostomy, with gastric resection a year later for a marginal ulcer. He died elsewhere, nine years later, from hemorrhage from a marginal ulcer. A second case died of pneumonia seven years after closure and a gastro-enterostomy. Autopsy showed pneumonia and empyema. Two cases died, five and five and one-half years, respectively, after simple closure, from pulmonary embolism, proven at autopsy. Both cases had been readmitted with ulcer symptoms and were under medical treatment at the time of death. A fifth case died of peritonitis one year after closure and a gastro-enterostomy, of undetermined cause. He had been operated upon and drained (Table XXIV).

GASTRO-INTESTINAL PERFORATIONS

TABLE XXI

ANALYSIS OF OPERATIVE MORTALITY IN CASES OF PERFORATED GASTRIC ULCER

Case	Time of Perforation		Age	Temp on Adm	Pulse on Adm	Operation	Time Post Operation	Cause of Death	Autopsy Findings
1	3	hrs	57	101°	120	Closure	2 hrs	Cardiac failure	
2	2	hrs	60	99°	80	Closure and gastro-ent	3 days	Peritonitis	Peritonitis
3	48	hrs	37	100 4°	128	Closure	2 days	Peritonitis	
4	3½	hrs	30	99 6°	94	Closure and gastro-ent	3 days	Peritonitis	
5	8	hrs	42	100 8°	88	Closure and gastro-ent	1 day	Gastric hemorrhage	Gastric hemorrhage
6	24	hrs	44	103 2°	122			Peritonitis (moribund)	
7	5	hrs	38	101 4°	80	Closure and gastro-ent	2 days	Pneumonia	
8	21	hrs	47	102 0°	114	Closure	53 days	Subphrenic abscess and peritonitis	
9	13	hrs	29	101 2°	100	Closure and appendectomy	4 days	Peritonitis	
10	36	hrs	19	98 6°	140	Closure	1 day	Peritonitis	
11	11	days	66				4 hrs	Peritonitis (moribund)	Perforated Gastric Ulcer and peritonitis
12	24	hrs	60	101 2°	110	Closure	2 days	Peritonitis	
13	48	hrs	53	100°	100	Closure	6 days	Peritonitis	Peritonitis
14	2½	hrs	50	99°	60	Closure	8 days	Pneumonia	
15	48	hrs	33	100 8°	104	Closure	4 days	Peritonitis	
16	8	hrs	75	99 2°	78	Closure	7 days	Pneumonia	Pneumonia, 2nd ulcer in duodenum
17	12	hrs	52	101 4°	104	Drained	9 days	Peritonitis	
18	24	hrs	66	102 8°	96	Closure	7 days	Peritonitis	
19	6	hrs	56	98 8°	90	Closure	6 days	Pneumonia and peritonitis	Pneumonia and peritonitis
20	4	days	58	103 2°	108	Closure	4 days	Peritonitis	Peritonitis, 2 Ulcers Perforation of anterior one
21	2	hrs	50	98 6	76	Closure	11 days	Pneumonia (bilateral)	
22	24	hrs	39	100 6°	124	Closure	2 days	Peritonitis	

TABLE XXII

ANALYSIS OF OPERATIVE MORTALITY IN CASES OF PERFORATED DUODENAL ULCER

Case	Time of Perforation	Age	Temp on Adm	Pulse on Adm	Operation	Time Post Operation	Cause of Death	Autopsy Findings
1	2 hrs	44	100°	90	Gastric resection	On table	Cardiac failure	
2		43					Died 10 min after admission	Perforated duodenal ulcer and peritonitis
3	4 hrs	43	99 6°	114	Closure and gastro-ent	7 days	Lung abscess	
4	24 hrs	54	99°	90	Closure	19 days	Subphrenic abscess	
5	48 hrs	61	100 8°	110	Closure	12 days	Peritonitis	Peritonitis perforation of gall-bladder Stone in common duct
6	4 days	45	100 6°	120		10 hrs	Peritonitis	Peritonitis Perforated duodenal ulcer (1 inch)
7	48 hrs	63	103 4°	128	Closure	1 day	Peritonitis	
8	5 hrs	63	102°	120	Closure	7 days	Pneumonia	Pneumonia Perforation (1 of 2 ulcers) and diverticulum of duodenum

TABLE XXIII

SUMMARY OF STATISTICS IN TABLES XXI AND XXII OF THE CASES DYING FOLLOWING OPERATION FOR PERFORATED GASTRIC AND DUODENAL ULCERS

	Time of Perforation	Age	Temp	Pulse	Time Post Operation	Peritonitis	Pneumonia	Cardiac Failure	Cause of Death Subphrenic Abscess	Hemorrhage	Lung Abscess
Gastric ulcers, 22 cases	32 8 hrs	48	100 6°	100	6 days	14	5	1	1	1	
Duodenal ulcers 8 cases	32 4 hrs	52	100 8°	110	5½ days	4	1	1	1		1

GASTRO-INTESTINAL PERFORATIONS

TABLE XXIV

ANALYSIS OF LATE MORTALITY FOLLOWING OPERATIONS UPON PERFORATED GASTRIC ULCERS

First Operation	Later Symptoms or Operation	Cause of Death	Autopsy Findings
1 Closure plus gastro-enterostomy	Marginal ulcer and gastric resection, 1 yr later	Died elsewhere 9 yrs later, from hemorrhage	
2 Closure plus gastro-enterostomy	Pneumonia, 7 yrs later	Pneumonia	Pneumonia and empyema
3 Closure	Ulcer symptoms, 5½ yrs later	Sudden	Pulmonary embolism
4 Closure	Ulcer symptoms, 5 yrs later	Sudden	Pulmonary embolism
5 Closure plus gastro-enterostomy	Peritonitis, 1 yr later	Peritonitis, cause unknown	

Two of the duodenal ulcer cases that had had simple closure died later. One had a second perforation 22 months after the first and died of peritonitis following operation (confirmed by autopsy). Another patient was readmitted six weeks after discharge following primary closure and died from pneumonia and nephritis soon after this admission (Table XXV).

TABLE XXV

ANALYSIS OF LATE MORTALITY FOLLOWING OPERATIONS UPON PERFORATED DUODENAL ULCERS

First Operation	Later Symptoms or Operation	Cause of Death	Autopsy Findings
1 Closure	Closure and perforation, 22 mos later	Peritonitis	Peritonitis and myocarditis
2 Closure	Bronchopneumonia plus nephritis, 6 wks. later	Pneumonia	

TO BE CONTINUED

POSTAPPENDICEAL ABSCESS IN THE RECTOVESICAL POUCH TRANSRECTAL DRAINAGE

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ANY FURTHER REDUCTION in the tragically large number of deaths occurring annually because of disease beginning in the appendix must be obtained by more successful treatment of its complications. Definite advance in the more efficient care of the late cases has been made in recent years. A more studied judgment as to the proper time to operate is seen, together with a will to delay, if it seems wise, against the importunities of family and friends. The disease is being allowed to subside completely in more patients, who return later for a safe interval appendicectomy. The nasal catheter to which Wangenstein²⁴ added continuous suction, the Miller-Abbott intestinal tube which Abbott and Johnston^{1, 14} have applied to ileus and obstruction, the wider use of parenteral fluids which Collet and Maddock⁹ have indicated how to employ with greater accuracy, and the simplification and freer use of blood transfusion, have aided materially in improving the treatment of peritonitis, ileus, obstruction and malnutrition.

Abscess in the rectovesical pouch following removal of the acute or early perforated appendix is one complication which has not received the emphasis it deserves, either as to diagnosis or treatment. As to the latter particularly, there is a marked divergence of opinion. The diagnosis, we must conclude, is not made, all too often, because this condition is not even in mind. During the last three years my associates and I have seen 26 cases which in our judgment have required drainage of an abscess in the rectovesical pouch. Twenty-one of these have occurred in 785 cases at Receiving Hospital, thus, at a rate of 2.67 per cent. The other five have been seen in consultation. The incidence here is estimated at a lower figure, as would be expected in private patients. It has become perfectly evident that the more constantly we have this complication in mind the more often we find it.

The picture is in part the same as that of any other concealed abscess, irregular fever, malaise, lack of appetite and elevation of the leukocyte count. More often this appears somewhere from the fourth to the seventh postoperative day to spoil what promised to be a happy convalescence. Not infrequently, however, the postoperative course is unsatisfactory from the beginning, the fever, distention and leukocytosis showing little evidence of approaching normal. Nather and Ochsner¹⁷ add a third general type which appears much later. We have not yet seen a case belonging to this group. Frequency of stool is common, often with the complaint of fullness in the rectum which def-

ecation does not relieve. Mucus is usually present in the stool. In two cases reported here this was so abundant that practically clear mucus was extruded from the anus almost constantly. Bailey² says this is pathognomonic of abscesses in the rectovesical pouch. Haggard¹³ would seem to agree. This has proven true in our experience. It is due to excessive stimulation of the mucous glands of the rectum by the adjacent infection. If the abscess is in contact with the bladder wall, there may be urinary symptoms consisting of frequency, urgency, even tenesmus and pain. The urine may show pus cells. We have found this in but two cases in this series. However, one was quite severe, having in addition, edema of the scrotum extending to the perineum.

Some degree of distention of the small intestine, from that questionable upon inspection but evident from increased tympany in the lower abdomen, to extensive ballooning, has been determined to be present in every case. In nine cases it amounted to clinical obstruction, with colicky pain, nausea, vomiting, increased audible peristalsis, and confirmatory plain roentgenogram. Since this has been so prominent in our experience we emphasize the necessity of looking for a pelvic abscess when obstructive symptoms appear in the post-operative course of perforative appendicitis.

Relaxation of the rectal sphincter is probably present to some degree in every case. Since the tonus of the sphincter is not constant in all persons it is often difficult to be certain of this sign unless daily rectal examinations are made by the same surgeon, and with this point definitely in mind. It can be ascertained with assurance in well over 50 per cent of cases and is of great value in making the diagnosis.

As the finger reaches a point just above the prostate a mass is felt. It usually bulges into the anterior rectal wall, often to a marked degree, is soft and cystic, suggesting that fluctuation might be obtained if the mass were accessible to two fingers. This sensation is not always present, however. At times, when the abscess has formed slowly, or has been discovered late, the mass is indurated and pitting edema will be a palpable finding. Tenderness is present but the degree is usually surprisingly less than the exquisite tenderness associated with confined pus. Some, and probably most, abscesses in the rectovesical pouch form there because of immediate gravitation of infection following perforation. In these, tenderness is at first the only evidence of the impending pathology, the mass forming later. It is interesting to note that in a few cases the abscess formed higher up and its progress downward could be followed until it reached the midline just above the prostate. In some it could be felt suprapubically before the finger in the rectum could reach it.

There is, so far, no unanimity of opinion as to what may be done at the primary operation to prevent the formation of pelvic abscess. The argument centers around the question of drainage. It swings from the dogmatic position of Brunn⁵ and others, never to drain in pelvic appendicitis to that of Eliot and Pickhardt,¹¹ and Evans,¹² who believe such abscesses indicate defective drainage. Eliot and Pickhardt advise washing out the pelvis with saline, sponging dry, and placing a drain down into the rectovesical pouch. Sloan²²

believes that leaving the pelvic drain in place for a week and withdrawing it at the rate of 2 cm a day will reduce the incidence Brunn,⁵ however, expects some abscesses to occur, but does not greatly fear them The practice to-day is largely midway between these extremes Most cases with free fluid in the pelvis are probably treated by removing the fluid by suction and inserting a pelvic drain In three of our cases there was no drain used, in seven, a drain was placed in the pelvis, and in the remainder in the right lower quadrant Any fluid present was removed by suction This seems to indicate that a certain number of abscesses will form in the rectovesical pouch no matter what procedure is used We have the impression that usually a drain in the pelvis is more apt to do harm than be of value Buchbinder⁶ believes that drains, in the presence of spreading infection, provoke residual abscesses

In the treatment of pelvic infection following appendicitis, there is agreement only in so far as conservative methods go Local heat, by irrigation or diathermy, together with general supportive measures, will see many infections clear up and even abscesses be absorbed

Disagreement becomes evident when the method of drainage is considered It is not the purpose of this paper to discuss drainage, but rather to advocate, as strongly as possible, the transrectal approach for abscess in the rectovesical pouch The only condition is that the diagnosis be certain That this is not difficult is shown by the fact that we have found pus in every case so approached Our results bear out the contention that this method is not only clinically sound, but the safest one All patients recovered Eight had clinically complete and one a partial obstruction All were relieved almost at once following drainage Convalescence was rapid Three patients were discharged in three days, and five in four days The average for the group was 8.7 days Carson⁸ noted that recovery was "amazingly rapid" I am thoroughly satisfied that no other method of treating these cases, several of whom were desperately ill, could have been attended with no fatality

Objections to transrectal drainage are constitutional, theoretic, technical and arbitrary, but, withal, they are more generally accepted than are the points in favor Thorek²³ says the suprapubic approach to pus in the pelvis is always preferable to evacuation through the rectum Bailey³ insists this blind procedure has a well-earned reputation of being dangerous, and has justly been replaced by the saner suprapubic route Very many will agree with these statements Some authors do not mention this route, even to condemn it But let us look at the objections to see how real they are and whether they can be overcome

(1) It is unsurgical to enter the peritoneal cavity through such a grossly infected area as the rectum That would be true if it stated the whole case But it does not The free peritoneal cavity is not entered Only a small, walled-off portion is involved, and it is already infected It is just another location where so-called "extraperitoneal drainage" may be effected We have seen no evidence that infection has been carried in, and have found no report of this by those who follow this plan

(2) It is a blind procedure. Is it any more so than the extraperitoneal drainage of any other intra-abdominal abscess? The posterior approach to subphrenic abscess proposed by Ochsner and Graves,¹⁹ which has greatly reduced the mortality in that condition, could be called blind and must be carefully performed to prevent catastrophe. The blindness of transrectal drainage would seem to consist in the size of the anal sphincter and the fact that one cannot visualize the surrounding structures, which should not be done when the location of an abscess anywhere is known.

(3) Fecal fistula may be produced by perforating a loop of small bowel. If the diagnosis is correct the small bowel will float on top of the pus and form part of the upper wall of the abscess. Therefore, it cannot be damaged. If such an accident should occur the opening would spontaneously close almost certainly, since that is the habit of enterostomies where obstruction does not exist.

(4) Herniation of small intestine through the opening into the rectum may occur. McGregor¹⁵ reports such a case. This complication could only occur if the incision in the rectal wall were far too large and in a very early case. This can in no way be an objection to the operation, but to the way it is performed.

(5) Severe hemorrhage may occur from the rectal wall. Since the blood supply enters the wall posteriorly, only terminal vessels are present at or near the midline anteriorly, to which area the drainage should be limited. Nather and Ochsner¹⁷ advise a midline incision in the long axis of the rectum, while Evans¹² suggests that a transverse incision is more apt to avoid larger vessels. Carson⁸ believes the direction of the incision is of no consequence. We believe the opening should be made largely by a blunt instrument which gives a further safeguard. Should a vessel of sufficient size to cause hemorrhage be inadvertently severed it can easily be controlled. There has been no hemorrhage in this series.

(6) There is danger of entering the bladder. This is a hazard to be kept constantly in mind. Richie²⁰ advised routine preoperative catheterization. This is good advice where any doubt exists. We have seen a suspected abscess disappear through the catheter after the patient had voided. However, if the surgeon assures himself that the bladder is empty as well as that there is an abscess in the rectovesical pouch, the bladder will never be injured.

(7) The drainage opening will be constantly reinfected from inside the rectum and may not close. This seems to be a wholly theoretic objection since no one seems to have had such an experience. Moynihan,¹⁶ who used this approach, commented upon the rapidity of closure following such incision. Some have felt that active measures should be taken to prevent closure too soon. Many advise a drain for several days. Burnett,⁷ Downey,¹⁰ Thorek,²³ and others suggest keeping the opening patent by frequent insertion of finger or instrument.

It would seem that we are justified in concluding that if the surgeon brings to this operation the same relative knowledge of anatomy, surgical and diag-

nostic ability as he does to procedures elsewhere in the body, none of these objections can be valid. In the 26 cases in this series, as well as in several others in which this approach has been employed by us to drain abscesses in the rectovesical pouch other than postappendiceal, no support for any of the above objections has been encountered.

Considered judgment as to just when the patient needs this operation is important. As suggested above, many infections in the rectovesical pouch, and some abscesses, will be absorbed just as they are higher up and need no drainage. Others will rupture spontaneously through the rectum, more frequently in children, but Boyce and McFettridge⁴ warn against leaving too much to nature. When the abscess is large and early, even though very definite, delay, if the general condition will permit until the adhesions forming the wall are fairly firm, will prevent pus breaking through and back into the general peritoneal cavity as the abscess collapses. On the other hand, waiting too long may precipitate this very serious and usually fatal complication. We have seen this occur twice, once in a postoperative case which ruptured spontaneously both through the rectum and back into the general cavity (autopsy), and once in a primary pelvic abscess, doubtless of appendiceal origin (no autopsy). Both patients died promptly. The danger of rupture into the bladder or retroperitoneal tissues must be considered. In the presence of obstruction with abscesses in the rectovesical pouch, drainage should be prompt. If the abscess is large and early, only a very small opening should be made, permitting slow evacuation. Santy²¹ warns against too rapid emptying when adhesions are yet not well organized.

The technic of the operation should be both simple and safe. Anesthesia is usually not necessary. The indications for it are youth, lack of cooperation, fear, and marked tenderness. A small amount of novocain (50 mg) intraspinally is used for adults, and gas for children. Since the diagnosis of the condition and judgment as to suitability for transrectal drainage is largely made by digital examination, no better guide for incision can be used than the finger. Dilatation of the sphincter is unnecessary to facilitate either the operation or subsequent drainage. No speculum is used. The end of the index finger determines the point for drainage. Upon it a thin curved scissors is carried in, the mucosa is incised, the scissors closed, thrust into the abscess, slightly opened and withdrawn. The opening should not be large enough to admit the finger. We do not employ a drain, preferring to reopen if necessary. This has been necessary only once.

We definitely disagree with the plan of making a preliminary suprapubic incision to locate the abscess and ascertain that it is well walled-off from the general cavity. This we believe to be entirely unnecessary, prolongs convalescence unduly and in at least one-third of our cases would in all probability have caused a fatal termination. Buchbinder⁶ correctly, we think, objects to pushing the finger down the old drainage tract, because the rectal approach is safer.

That drainage of abscess in the rectovesical pouch by the suprapubic ap-

proach, with uphill drainage through an uninfected portion of the peritoneal cavity is not entirely satisfactory, is attested by the various methods devised to avoid it. Some of these, aside from the transrectal, are inguinal, perineal, coccygoperineal, parasacral and ischiorectal. The transrectal is the simplest, most direct, least mutilating, least productive of complications, and will be accompanied by the lowest mortality.

SUMMARY AND CONCLUSIONS

(1) Attention is drawn to the occurrence of abscess in the rectovesical pouch following operation for acute and perforative appendicitis.

(2) Symptoms and signs are reviewed which should lead to a positive diagnosis. Frequent rectal examinations should be made postoperatively in all cases of perforative appendicitis.

(3) Its relation to intestinal obstruction as an etiologic factor is emphasized.

(4) Transrectal drainage is advocated as the method of choice in the male. A simple technic is described.

(5) Objections to this approach are discussed.

(6) This procedure has been employed in 26 cases, with recovery in all.

REFERENCES

- ¹ Abbott, W. Osler, and Johnston, Charles G. Intubation Studies of the Human Small Intestine. *Surg, Gynec, and Obstet*, 66, 691, April, 1938.
- ² Bailey, Hamilton. Drainage of a Pelvic Abscess per Rectum. *Lancet*, 213, 754, 1927.
- ³ Idem. Emergency Surgery. New York, William Wood & Co., 1, 60, 1930.
- ⁴ Boyce, F. F., and McFettridge, E. M. The Essential Clinical Considerations of Acute Appendicitis. *Internat Surg Dig*, 22, 195, October, 1936.
- ⁵ Brunn, H. Acute Pelvic Appendicitis. *Surg, Gynec, and Obstet*, 63, 583, November, 1936.
- ⁶ Buchbinder, J. R. Surgical Limitations in the Treatment of Acute Suppurative Peritonitis. *Surg, Gynec, and Obstet*, 59, 485, September, 1934.
- ⁷ Burnett, W. E. Rectal Drainage of Pelvic Abscess in Males. *Surg Clin N Amer*, 14, No 1, 155, 1934.
- ⁸ Carson, H. W. Modern Operative Surgery. New York, William Wood & Co., 2, 6, 1925.
- ⁹ Collier, Frederick A., and Maddock, Walter G. Dehydration Attendant on Surgical Operations. *J A M A*, 99, No 2, 875, September 10, 1932, The Water Requirements of Surgical Patients. *ANNALS OF SURGERY*, 98, 952, November, 1933, A Study of Dehydration in Humans. *ANNALS OF SURGERY*, 102, 947, November, 1935.
- ¹⁰ Downey, D. S. Management of Peritonitis Due to Pelvic Infection. *Jour Oklahoma Med Assn*, 23, 20-22, 1930.
- ¹¹ Ehot, E., Jr., and Pickhardt, O. S. The Management of Pelvic Abscesses in Acute Appendicitis. *ANNALS OF SURGERY*, 74, 480-489, 1921.
- ¹² Evans, I. A. Rectal Approach to Pelvic Abscess Complicating Acute Appendicitis. *Minnesota Med*, 5, 477-481, 1922.
- ¹³ Haggard, W. D. Appendicitis. *Am Jour Surg*, 28, 71-77, April 1935.
- ¹⁴ Johnston, Charles G. Decompression of the Small Bowel by Intestinal Tube Drainage at Site of Obstruction. *Jour Mich Med Soc*, 37, 623, 1938.
- ¹⁵ McGregor, A. Lee. *Brit Jour of Surg*, 24, 292, October, 1936.

- ¹⁶ Moynihan, Sir Berkley Abdominal Operations Philadelphia, W B Saunders Co, 2, 208, 1926
- ¹⁷ Nather, C, and Ochsner, A Douglas Abscess Following the Closed Treatment of Peritonitis Surg, Gynec, and Obstet, 258, February, 1925
- ¹⁸ Ochsner, A, Sage, J M, and Garside, E Intra-abdominal Postoperative Complications of Appendicitis, ANNALS OF SURGERY, 91, 544, 1930
- ¹⁹ Ochsner, A J, and Graves, A M Subphrenic Abscess ANNALS OF SURGERY, 98, 961, December, 1933
- ²⁰ Richie, H P Rectal Section for Pelvic Abscess J A M A, 424, August 10, 1918
- ²¹ Santy, M P Lyon Med, 23, 646, 1926
- ²² Sloan, H G In Lewis, Dean Practice of Surgery Hagerstown, Md, W F Pryor Co, Inc, 7, Chap 3, p 35, 1930
- ²³ Thorek, Ma\ Modern Surgical Technic, Philadelphia, J B Lippincott Co, 3, 1480, 1938
- ²⁴ Wangenstein, O H Therapeutic Considerations in the Management of Acute Intestinal Obstruction Arch Surg, 26, 933, June, 1930

THE PRESENT STATUS OF CARCINOMA OF THE GALLBLADDER

A STUDY OF THIRTY-FOUR CLINICAL CASES

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IN PRESENTING a communication on carcinoma of the gallbladder, the author is inclined to agree with Boyce and McFetridge,¹ who stated that at the present time there is little or no excuse for the publication of a small series of cases. However, when these cases were reviewed, and it was found that only one out of 34 was cured, and that a correct preoperative diagnosis was made in only four cases, it appeared that the condition deserved continued study.

There is disagreement regarding the incidence of carcinoma of the gallbladder. Since very few cases are cured, we should be able to obtain an idea of the prevalence from the Bureau of Census mortality statistics. There is difficulty, however, because in these statistics all carcinomata of the biliary tract are grouped together. Graham,² in 1931, noted that carcinoma of the gallbladder and liver accounted for almost 10 per cent of all deaths from carcinoma in 1926, and he felt that most of these were primary in the gallbladder. This assumption demands scrutiny. Judd and Gray³ studied 312 cases of carcinoma of the gallbladder and ducts, and found that approximately one-half of the cases occurred in men, and one-fourth of those in women were primary in the ducts. In addition, a small number of malignancies of the liver are primary liver-cell carcinomata. In a recent study,⁴ 16 malignant hepatomata, seven cholangiomata, and six primary tumors of the extrahepatic ducts were noted in 6,050 autopsies, carcinoma of the gallbladder was, however, encountered in only 11 cases.

The mortality statistics for 1936⁵ indicate that 65,545 males and 77,068 females died from all forms of cancer, a total of 142,613, 4,490 men and 5,935 women died of malignancy of the biliary tract, a total of 10,420, which is approximately 7 per cent of all cancer deaths. If we accept the proportions of gallbladder and duct carcinoma of Judd and Gray as being representative, 3,729 of the cases of biliary tract malignancy would be considered as duct carcinoma, leaving 6,691 cases, of which some are primary liver-cell tumors. It would seem reasonable to estimate that about 6,500 persons in the United States died of primary carcinoma of the gallbladder in 1936. This is 4.5 per cent of the total malignancy deaths, or about one-half the percentage estimated by Graham for 1926. This difference is due to the fact that total cancer deaths increased more than 40 per cent during the ten-year period, while carcinoma of the biliary tract increased less than 10 per cent, and deductions were made for duct and primary liver carcinoma.

Submitted for publication March 27, 1939

The disease is not found very frequently in operations upon the biliary tract. Boyce and McFetridge collected 35,054 operations upon the gallbladder from the literature, and in these there were 393 cases of carcinoma of it, an incidence of 1.12 per cent. A higher incidence is noted in individual series of cases. Cooper⁶ had 48 cases in 1,500 operations, or 3 per cent. In women with cholelithiasis, the disease is more common. Lentze⁷ found it in 4.3 per cent of cases, and Graham in 8.5 per cent. The incidence in autopsy material was 0.33 per cent in 13,034 autopsies collected by Boyce and McFetridge, and 0.61 per cent in 2,941 autopsies in Cooper's series.

Clinical Phenomena—As stated in the opening paragraph, one of the purposes of this analysis was an attempt to clarify the picture of carcinoma of the gallbladder, so that a greater percentage of correct preoperative diagnoses could be made. It will be readily admitted that greater success in diagnosis may not affect the end-results, indeed, overemphasis of gallbladder malignancy as a diagnostic possibility might cause surgery to be withheld in certain cases of jaundice of benign origin. However, from other standpoints, more accurate diagnosis is desirable. Therefore, the clinical picture of the disease, as it appears from this series, will be presented and compared with the reports of others.

Age, Race, and Sex—Carcinoma of the gallbladder is a disease of the "cancer age." The youngest case was 46, the oldest 82. Eighty per cent of cases of carcinoma of the gallbladder will be over 50 years of age, and, with rare exceptions, the others will be in the late forties. Cooper reported the condition in a patient 28 years of age, which is the youngest in the recent literature (Table I).

TABLE I
AGE DISTRIBUTION

Age Group	No. of Cases	Per Cent
46-49 years	4	12
50-59 years	10	29
60-69 years	13	38
70-79 years	6	18
80-82 years	1	3

There were 23 females and 11 males in this series, a ratio of 2.1. Others, such as Finsterer⁸ and Illingworth,⁹ have reported ratios as high as 4.1. The ratio usually given in this country is 3.1. With regard to race, all of the cases in this series were white, but two recent reports,^{1,9} indicate that the disease is not infrequently seen among the Negroes of the South.

History—The disease begins rather acutely in many cases. Forty-one per cent of the patients stated that the present illness was of less than one month's duration, 32 per cent gave one to three months, 12 per cent, three to six months, and three had been sick for more than six months. Seventeen patients, half of the series, had symptoms suggesting benign biliary disease which antedated the present illness from one to 25 years.

The most frequent chief complaint was pain in the upper quadrant (11 patients, 32 per cent). Six listed jaundice, and four abdominal distress. Others were chiefly concerned with nausea, pain in the back, belching, tumor, anorexia, constipation, and indigestion. Pain was an almost constant symptom, being present in 30 cases (88 per cent). This was in the right upper quadrant in 15 cases (44 per cent), and epigastrium in 11 cases (32 per cent). Two patients complained of generalized abdominal pain, two had pain in the back and right side, and four did not have pain. Twenty-one patients (62 per cent) had nausea, and 18 (53 per cent) vomited. Slightly more than half of the cases were jaundiced. Weight loss was not prominent, since only 13, or 38 per cent, had lost ten pounds or more. Cooper found weight loss in 95 per cent of his cases, while others^{10, 11} reported that half of their patients had lost weight.

Physical Findings—The findings with regard to tenderness are shown in Table II. It should be noted that 41 per cent of the cases did not have tenderness, and if tenderness was present, it was usually in the right upper quadrant. A tumor in the region of the gallbladder was palpable in 12 cases, or 35 per cent. Most of the authors quoted in this paper found a tumor present in slightly more than half of the cases. In our series, the liver was palpable in 16 cases (47 per cent). This is in accord with the experience of other writers.

TABLE II
LOCATION OF TENDERNESS

	No. of Cases	Per Cent
Right upper quadrant	16	47
No tenderness	14	41
Epigastrium	2	6
General	2	6

Laboratory Data—The rarity of marked anemia in carcinoma of the gallbladder has been noted by others. Judd and Baumgartner¹² studied 56 cases, and found only five with a hemoglobin less than 70 per cent. The average was 73 per cent. This was felt to be within the normal limits. Twenty-nine of the cases in this series had a hemoglobin recorded. Of these, 18, or 62 per cent, had values above 80 per cent, and seven had values between 70 and 79 per cent. In other words, over 85 per cent of the cases did not have a well-marked anemia. The Wassermann test was recorded in 31 cases. It was negative in all except the one five-year survival. Leukocyte counts were recorded in 30 cases. Seventeen of these were normal, 12 were between 10,000 and 15,000, and there was one extremely high count of 25,000. The bromsulphalein test was done for only two patients. These showed 55 per cent and 25 per cent retention, respectively, of the dye in 30 minutes, and, subsequently, extension to the liver was noted. Diagnostic transduodenal biliary drainage was done in 16 cases. This was reported as normal in six cases, negative for bile in four cases, no "B" bile in two

cases, positive for crystals suggesting cholelithiasis in three cases, and scant bile was obtained in one case. These findings were of no assistance in making the diagnosis of malignancy. Since gallbladder bile ("B" bile) was obtained in nine cases out of 16, or more than half, it seems possible that a careful histologic investigation of the bile for malignant cells might be worth while.

Roentgenologic Diagnosis—Cholecystograms were made in nine cases. All of these showed nonfilling of the gallbladder, and only one roentgenogram showed positive stones. Kirklin,¹³ in reporting his experience in the cholecystographic diagnosis of neoplasms of the gallbladder, stated that he was able to diagnose papilloma and adenoma with considerable accuracy, but had not yet made a diagnosis of carcinoma of the gallbladder. He reviewed the roentgenograms on 16 cases of proven carcinoma of the gallbladder, and found that 14 of these gave no shadow of the dye, half showed positive stones, one showed stones with, however, good function, and one had a normal cholecystogram. Cooper reported a similar experience. Rarely, carcinoma of the gallbladder may be strongly suspected, when the barium meal or enema demonstrates a fistulous connection between the gallbladder and the stomach or colon. Two such cases, with correct preoperative diagnoses, were described by Spitzenberger.¹⁴ In summary, we may say that a nonfilling gallbladder, with or without positive stone shadows, is to be expected in carcinoma of the gallbladder.

Judd and Baumgartner suggested that cases of carcinoma of the gallbladder may be divided roughly into three groups. Group I, consisting of those cases with a history of colic or other symptoms of benign biliary disease for several years, with superimposed symptoms and signs of malignancy, namely, constant pain, loss of weight, anorexia, and the appearance of tumor; Group II, containing those cases which simulate benign biliary disease until operation; Group III, containing those cases in which there is a rather sudden onset of the malignant phase, sometimes without definite indication that the disease is in the gallbladder. The cases in this series were allocated in these categories, and compared with the series of Judd and Baumgartner (Table III).

TABLE III
PERCENTAGE OF CASES IN THE THREE CLINICAL GROUPS

	Judd and Baumgartner ¹²	This Series
Group I	70%	26%
Group II	22%	44%
Group III	9%	29%

The preoperative diagnoses in the 34 cases of this series are shown in Table IV.

Discussion of the Clinical Picture—It is difficult to set up diagnostic criteria for carcinoma of the gallbladder. From the above study, a typical case might be described as follows. The patient, female, about age 60, states

CARCINOMA OF GALLBLADDER

TABLE IV
PREOPERATIVE DIAGNOSES

Diagnosis	No of Cases	Per Cent
Cholecystitis	12	35
Carcinoma of pancreas or ducts	9	26
Carcinoma of gallbladder	4	12
Carcinoma of liver	2	6
Common duct stone	2	6
Cirrhosis of liver	2	6
Intestinal obstruction	2	6
Carcinoma of stomach	1	3

that her trouble began about a month previously, but as likely as not, she has had biliary colic for a number of years. She complains of pain in the right upper quadrant which is steady and severe. She is apt to have nausea and vomiting. She may or may not be jaundiced. There is little if any weight loss, and she is not anemic. She probably has tenderness in the right upper quadrant, and the chances are even that a tumor, as well as the liver, is palpable. Cholecystograms show nonfilling of the gallbladder, with or without stone shadows. Other gastro-intestinal studies are negative.

This picture will fit many cases of benign biliary disease or cancer in organs other than the gallbladder. In making the differential diagnosis, the following points might be stressed. Advanced age, steady pain, tumor (particularly if it is not tender), weight loss, absence of leukocytosis, and a persistent downhill course point toward malignancy rather than an inflammatory condition.

The treatment of the cases in this series is indicated in Table V. In three of the cases in which cholecystectomy was performed, carcinoma was not suspected at the time of the operation. Therefore, a deliberate attempt to

TABLE V
OPERATIVE PROCEDURES

	No of Cases	Per Cent
Exploration and biopsy	23	68
Cholecystectomy	6	19
Cholecystectomy and implantation of radium	3	9
Cholecystostomy	1	3
No operation (autopsy)	1	3

remove the carcinoma was made in only six cases, or 18 per cent. These cases all died. The malignancy in the gallbladder of the one five-year survival in this series was not suspected until the routine histologic examination was made. Others have performed cholecystectomy more often. This was done 16 times in 48 cases in Cooper's series. He could report only one patient alive after two years. Judd and Gray had 59 cholecystectomies in 212 cases, and palliative procedures as follows: Cholecystostomy in 42, some type of anastomosis in 27.

A radical operation for carcinoma of the gallbladder has been suggested by several authors. Gray¹⁵ described a method of removing the

gallbladder together with a portion of the liver, using the electrocautery. His one case recovered from the operation, but the end-result was not stated. Finsterer had one survival in 46 cases, in which instance he performed a resection of the contiguous portion of the liver. Microscopic sections on his case showed that carcinoma had invaded the full thickness of the gallbladder wall, but had not actually penetrated the liver substance. He advised partial hepatectomy, if carcinoma is suspected at the time of the operation. Another single case report is that of Aiga,¹⁶ who removed the gallbladder, a portion of the common duct, and a large mass of necrotic tumor tissue from the common duct. The patient was alive after seven and one-half years.

In this series, the duration of life after operation was as follows: Less than one month, 18 cases; one to three months, five cases; three to six months, five cases; six months to one year, two cases; one to three years, three cases. One case is well and asymptomatic after five years.

Pathology—Gallstones were frequent. They were present in 20 out of 23 gallbladders which were opened, an incidence of 87 per cent. Judd and Gray found 64.6 per cent, and Cooper found 79 per cent.

With regard to the type of tumor, 28 were classified as adenocarcinoma (82 per cent), five were of the squamous variety (15 per cent), and one was mixed. The squamous cell variety was encountered more frequently than usual. Judd and Baumgartner found only three such tumors in 55 cases, and Cooper found only one in 48 cases. The various theories to explain the presence of squamous cell epithelium in this location have been discussed by Rabinovitch and Kieffer.¹⁷ The tumor had extended into the liver in 15 cases, into the common duct in four cases, the liver and common duct in four cases, the stomach in three cases, and the colon in one. There were metastases to the regional lymph nodes in six cases. In 11 autopsies, metastasis to the lungs was found only once. Occasionally, a lung tumor may be due to an unsuspected primary growth in the gallbladder, as in the case reported by Foggie and Tudhope.¹⁸

Prophylaxis—Since treatment for established carcinoma of the gallbladder has given such poor results, it has been repeatedly suggested that gallbladders with stones should be removed prophylactically. In 1931, Graham stated: "It would seem reasonable to conclude that at least 4 to 5 per cent of women of the cancer age who have stones, will develop carcinoma of the gallbladder. This would be much more than the operative mortality rate of 1 to 3 per cent." Even if the danger of loss of life from carcinoma of the gallbladder were the same or less than the danger from the operative procedure, cholecystectomy is indicated in the absence of symptoms because of the danger of complications other than malignancy. There should be more reports of series of cases like that of Jaguttis.¹⁹ He followed 114 cases of cholelithiasis which were treated conservatively for ten to 25 years. Five developed carcinoma of the gallbladder, 13 died of cholecystic disease, 25 were operated upon for complications, four of which died. This report considers mortality only, and does not take into account the suffering which probably accompanied the cholelithiasis in some of the survivors.

Status of Experimental Work in Carcinoma of the Gallbladder—It is generally thought that gallstones cause cancer from irritation, since they are found in 70 to 100 per cent of cases. However, the experimental proof of this causal relationship is lacking. In 1931, Burrows²⁰ gave a summary of the experimental work up to that time. He reviewed the work of Kazama, Leitch,²¹ Clemente, Delbert and Goddard, Petrov and Krotkina, and Gioia. This experimental work consisted of the introduction of various foreign bodies, especially human gallstones, into the gallbladders of experimental animals. Instances of carcinoma were reported as having developed in several animals, but the results have been discredited for various reasons. For instance, the work of Leitch is often quoted, but his paper was in the nature of a preliminary report, and part of his animals were still alive at the time of his publication. A final report did not appear. After seeing the reproductions of his photomicrographs, one would agree with Creighton,²² who stated "The conclusion, I think, from Dr. Leitch's experiments on the gallbladder should be that the guinea-pig is peculiarly apt to develop these epitheliated tubes in the interstices of the chronic inflammatory reaction. To judge from the few details and the low power photomicrographs, they lacked the large nuclei and the deep chromatinization of true cancer, and until further advised, I should hold the results in the same ambiguity as Dr. Leitch holds the Japanese guinea-pig experiments" (Kazama).

Petrov and Krotkina reported, in 1928, that they could not reproduce carcinoma of the gallbladder in the guinea-pig, by the introduction of foreign bodies, but in 1933, they²³ reported success. Nineteen guinea-pigs were used. Small glass tubes containing a microgram of radium were inserted into the gallbladders of 12 animals, and seven controls had empty glass tubes inserted. They were trying to confirm the work of Barlow, who had presented evidence that cancer of the gallbladder was due to the radioactivity of gallstones. They reported that carcinoma developed in two animals in each group. Three of the animals were said to have had multiple metastases, and died of cancer. The fourth was operated upon at the end of the experimental period, and a carcinoma of the common duct was found. However, these authors did not choose to publish photomicrographs of the tumor tissue, but submitted drawings instead. Hence, it can be stated that at the present time, experimental proof that gallstones cause cancer is lacking.

However, even though an etiologic relationship is not proved, or even if it is disproved, it is well established that the two conditions occur together, and if cholelithiasis is not the cause of cancer, it may be, at least, a warning sign.

SUMMARY

- (1) The present incidence of carcinoma of the gallbladder is discussed.
- (2) Thirty-four cases of carcinoma of the gallbladder are analyzed with respect to clinical picture and pathologic findings.
- (3) The question of prophylactic cholecystectomy in cholelithiasis is discussed.

(4) The difficulty in diagnosis and comparatively hopeless prognosis in evident cases is stressed

(5) The present status of experimental work on carcinoma of the gallbladder is summarized

The author is indebted to Dr Roy D McClure who suggested this study and operated upon most of the cases reported

REFERENCES

- ¹ Boyce, F F, and McFetridge, E M Carcinoma of the Gallbladder, Critique Based on Analysis of 25 Cases from Charity Hospital in New Orleans Internat S Digest, 21, 67-79, February, 1936
- ² Graham, E A Prevention of Carcinoma of Gallbladder ANNALS OF SURGERY, 93, 317-322, January, 1931
- ³ Judd, E S, and Gray, H K Carcinoma of the Gallbladder and Bile Ducts Surg, Gynec and Obstet, 55, 308-315, September, 1932
- ⁴ D'Aunoy, R D, Ogden, M A, and Halpert, B Primary Carcinoma of the Biliary System Surgery, 5, 670-678, May, 1938
- ⁵ United States Bureau of the Census Vital Statistics, Special Reports, 5, No 23, 63, April 5, 1938
- ⁶ Cooper, W A Carcinoma of the Gallbladder Arch Surg, 35, 431-448, September, 1937
- ⁷ Lentze, quoted by Graham²
- ⁸ Finsterer, H Das Karzinom der Gallenblase Med Klin, 28, 432-436, March 24, 1932
- ⁹ Illingworth, C F W Carcinoma of Gallbladder Brit Jour Surg, 23, 4-18, July, 1935
- ¹⁰ Rhodes, R L, and Greenblatt, R B Carcinoma of Gallbladder, Studies of 24 Cases in Georgia South Med Jour, 30, 315-318, March, 1937
- ¹¹ Shelley, H J, and Ross, L I Primary Carcinoma of the Gallbladder, Report of 19 Cases Arch Surg, 25, 65-83, July, 1932
- ¹² Judd, E S, and Baumgartner, O J Malignant Lesions of the Gallbladder Arch Int Med, 44, 735-745, November, 1929
- ¹³ Kirklin, B R Cholecystographic Diagnosis of Neoplasms of the Gallbladder Proc Staff Meet Mayo Clinic, 7, 384-386, August, 1932
- ¹⁴ Spitzenberger, O Zur Diagnose exulzerierender Gallenblasen-Karzinome mittels des Rontgenverfahrens Wien klin Wchnschr, 46, 1421-1423, November 24, 1933
- ¹⁵ Gray, H K Squamous Cell Epithelioma of the Gallbladder and Liver, Cholecystectomy and Partial Hepatectomy Report of a Case Surg Clin North Amer, 14, 717-720, June, 1934
- ¹⁶ Aiga, Y Uber einen seltenen Fall von operativ dauernd geheilten Gallenblasenkarzinom Zentralbl f Chir, 62, 212-215, January 26, 1935
- ¹⁷ Rabinovitch, J, and Kieffer, R Squamous Cell Carcinoma of the Gallbladder Surg, Gynec and Obstet, 52, 831-835, April, 1931
- ¹⁸ Foggie, W E, and Tudhope, G R Secondary Carcinoma of the Lung with Inconspicuous Primary in the Gallbladder Edinburgh Med Jour, 37, 632-637, November, 1930
- ¹⁹ Jaguttis, quoted by Finsterer⁸
- ²⁰ Burrows, H An Experimental Inquiry Into the Association Between Gallstones and Primary Cancer of the Gallbladder Brit Jour Surg, 20, 607-629, April, 1935
- ²¹ Leitch, A Gallstones and Cancer of the Gallbladder, an Experimental Study Brit Med Jour, 2, 451-454, September 13, 1924
- ²² Creighton, C Correspondence regarding Leitch's article Brit Med Jour, 2, 1079, December 6, 1924
- ²³ Petrov, N N, and Krotkina, N A Experimentelles Gallenblasen und Leberkarzinom Ztschr f Krebsforsch, 38, 249-263, 1933

CARCINOMA OF THE GALLBLADDER

A STUDY OF SEVENTY-FIVE CASES

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CARCINOMA OF THE GALLBLADDER is rarely diagnosed before the patient comes to operation or to autopsy. It was decided to study this group of cases for the purpose of learning whether there was any set of symptoms or signs or a combination of the two which specifically point to this diagnosis as against inflammatory lesions of the biliary tract or carcinomata adjacent to the gallbladder. The records of all patients having carcinoma of the gallbladder, in the files of the Michael Reese Hospital for the years 1922 through June, 1938, and those at Cook County Hospital for the years 1925 to 1937, inclusive, have been carefully examined. We have included in this study only those cases in which the diagnosis was proven either by a biopsy of the gallbladder or by postmortem examination. There were 44 cases at the Cook County Hospital, and 31 at Michael Reese Hospital, which met these criteria. Of these 75 cases, 27 had biopsies, 44 had autopsy examinations, and four had both.

We shall not review the literature in any detail as it has been so exhaustively considered by Cooper,¹ and Illingworth.² Although there have been over 2,000 cases reported in the literature since 1900, the series herewith presented, we believe, is the largest single group as yet reported.

Carcinoma of the gallbladder occurred in 31 males (41.3 per cent) and 44 females (58.7 per cent), or a ratio of approximately 3:4, which is a much higher incidence of this lesion in males than has been found in other statistics. In both Cooper's and Illingworth's series the ratio was 1:4, in Jankelson's³ it was 1:3. The ages range from 36 to 84 years, with the greatest number between the ages of 51 and 70 (62.7 per cent). Interestingly enough, there is no difference in the age range for the men and the women (Table I).

TABLE I

AGE INCIDENCE

Ages	Males	Females	Total
31-40		3	3
41-50	4	9	13
51-60	13	13	26
61-70	11	10	21
71-80	3	8	11
81 and over		1	1
Totals	31 (41.3%)	44 (58.7%)	75

Submitted for publication February 16, 1939

The symptoms (Table II) fall into two groups. Those occurring in more than half the cases, and those in less than half. In the first group, there is pain in the right upper quadrant and epigastrium in 50, or two-thirds of the cases, loss of weight in 43, or 57.3 per cent, and jaundice in 41, or 54.7 per cent. The pain was present for less than six months in 26 of the patients (60 per cent of those having pain) and for less than a year in 31 cases (76 per cent of those with pain). It was present for more than five years in 11 patients, of whom eight had pain for over ten years (Table III). In 29 patients, pain was the first symptom noted. It is interesting to note how frequently marked weight loss occurred in our patients, for Illingworth specifically states that weight loss is not a prominent symptom of carcinoma of the gallbladder, and it was observed in only eight of his 30 cases. Of the 41 patients with jaundice, six stated that it was the first intimation they had that anything was wrong. Incidentally, the presence of jaundice can probably be explained only by the fact that in metastasizing locally the lymph nodes surrounding the common duct are involved, thus producing pressure and obstruction.

TABLE II

SYMPTOMS

Symptoms	No. of Cases	Percentage of Cases
Pain { R U Q } { Epigastric }	50	67.0%
Weight loss	43	57.3%
Jaundice	41	54.7%
Anorexia	14	18.7%
Achoha	15	20.0%
Belching	29	38.7%
Weakness	16	21.3%
Nausea	14	18.7%
Vomiting	30	40.0%
Diarrhea	9	12.0%

TABLE III

DURATION OF PAIN

Duration	No. of Cases
Under 1 month	6
1-6 months	20
6 months-1 year	5
1-2 years	1
2-5 years	2
5-10 years	3
Over 10 years	8
Unknown duration	5

In 15 of our patients (Table IV), all three of the above symptoms were present, and in 33 cases, two of these three symptoms occurred in conjunction. While we realize that these symptoms are found together in lesions other than carcinoma of the gallbladder, we believe that if these three symp-

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toms were more widely recognized as relatively common in malignancy of the gallbladder, the diagnosis might be made more frequently than it is at present

In the second group of symptoms, namely, those occurring relatively infrequently, belching was complained of by 29 patients, vomiting was present in 30 cases, weakness in 16, anorexia in 14, and acholic stools in 15 cases. Only seven patients had chills and fever, and nine complained of diarrhea. No gross blood was noted in the stools, nor were tarry stools present according to the patient.

TABLE IV

CASES IN WHICH PAIN, WEIGHT LOSS AND
JAUNDICE WERE PRESENT IN COMBINATION

	No. of Cases
Weight loss and jaundice	5
Weight loss and pain	16
Pain and jaundice	12
Pain, weight loss and jaundice	15

On physical examination, jaundice was the most constant finding, being present at the time of admission or developing while under observation in 41 patients. The liver was enlarged in 41 patients (not the same 41 who had jaundice); in 12 of these patients, the examiner stated that the liver was nodular. In 15 of the patients with an enlarged liver, a mass was palpable below the liver. In an additional 16 patients, a definite mass was felt in the right upper quadrant which was not identified by the examiner, so that we cannot be sure whether it was liver or gallbladder or both. Ten patients had ascites of relatively advanced degree, despite this fact only two patients had a cirrhosis of the liver. In 20 patients (26.7 per cent), stool examinations showed occult blood.

Of the 75 patients studied, 53 (69.3 per cent) had stones in the gallbladder (Table V). Of the 31 men, 18 (58 per cent) had stones, 35 (79.5 per cent) of the 44 women had stones. Twenty-six women and 16 men who had stones in the gallbladders were between the ages of 41 and 70. The average age for men and for women with calculi in the gallbladder is about the same. The males without stones, however, average slightly higher in age than those with stones, while the women with or without stones are of about the same age.

TABLE V

INCIDENCE OF STONES

	Stones	No Stones
Females	35 (79.5%)	9 (20.5%)
Average age	59.4 years	57.8 years
Males	18 (58%)	13 (42%)
Average age	58.5 years	63 years

Four patients in the series had had a cholecystostomy previously. One had had the operation 16 years before the carcinoma was found, one had had it a year and a half previously, and one only five months before readmission.

to the hospital, the fourth patient could not recall when the operation had been performed. All four patients had stones in their gallbladders at the time that the cholecystostomy was performed. In addition to these four patients, six had been told that they had gallbladder disease, one, as long as 26 years before the carcinoma was found, one, as recently as a month before the final diagnosis, the others, at various lengths of time between these two extremes. Four of this group had stones in their gallbladders at the time that the carcinoma was discovered.

Thirty-nine patients were operated upon in the course of their stay in the hospital. Thirteen had an exploratory celiotomy performed, in seven of these, a biopsy was taken, the other six were closed without anything being done. Five patients had a cholecystostomy, four with a biopsy in addition, ten patients had a cholecystectomy, seven a cholecystectomy and choledochotomy, one a cholecystectomy with drainage of the hepatic duct, one a cholecystectomy and a choledochoduodenostomy, one a cholecystogastrostomy, and one a jejunostomy (Table VI). Of these 39 patients, 21 died while in the hospital or shortly thereafter. Of the remaining 17, one is believed by his physician to be alive. In that patient, a very small adenocarcinoma of the fundus of the gallbladder was found at the time that a cholecystectomy was performed. We have been unable to learn the fate of the other 16 patients who left the hospital alive. Undoubtedly the four patients in whom biopsies alone were done have died, as has the patient with the cholecystogastrostomy.

TABLE VI
OPERATIONS

Type	Total Cases	No. Died in Hospital
Exploratory	6	6
Exploratory with biopsy	7	4
Cholecystostomy	1	1
Cholecystostomy with biopsy	4	3
Cholecystectomy	10	3
Cholecystectomy and choledochotomy	7	3
Cholecystectomy and choledochoduodenostomy	1	
Cholecystectomy and drainage hepatic duct	1	
Cholecystogastrostomy	1	
Jejunostomy	1	1

The pathologic diagnoses for this series were: Adenocarcinoma in 52, carcinoma simplex in nine, colloid carcinoma in two, and metaplastic, squamous cell carcinoma in one case. In 11 patients, the type of carcinoma was not stated. (Because of technical difficulties we were unable to review the slides.) Invasion of the liver was present in two-thirds of the cases.

In general, our results seem to agree fairly closely with those of other investigators, the most outstanding difference in our group is the much higher percentage of males, 34, as compared with the nearest figure of 13.

CONCLUSION

(1) Seventy-five cases of carcinoma of the gallbladder, of whom 31 were men and 44 were women, are presented. The ages ranged from 36 to 84 years, with the maximum number between the ages of 51 and 70.

(2) Three symptoms occurred in over half the patients, these were pain in the right upper quadrant and epigastrium, loss of weight and jaundice.

(3) On physical examination, over half the patients had enlarged livers. Thirty-one had a palpable mass in the right upper quadrant, in 15 of these the mass was felt in addition to an enlarged liver.

(4) Sixty-nine and one-half per cent of the patients had calculi in their gallbladders.

(5) Pathologic study showed that the vast majority of the cases were adenocarcinomata.

REFERENCES

¹ Cooper, William A. Arch Surg, 35, 431, 1937

² Illingworth, C. F. Brit Jour Surg, 23, 4, 1935

³ Jankelson, I. R. New England Jour Med, 217, 85, 1937

TORSION OF A WANDERING SPLEEN

COMPLICATED BY DIAPHRAGMATIC HERNIA

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THE AMBULANCE SERVICE of the Knickerbocker Hospital, New York City, brings to the hospital a great many acutely ill patients who require immediate operative treatment. Acute, urgent surgery tests the acumen of a hospital staff in many ways. Frequently, these patients are admitted at night, when the more technical clinical and laboratory investigations cannot be made. This is an added handicap to the Junior Staff member who is called to see such patients. Usually, however, most emergency patients suffer from but a single acute disease, with exaggerated symptoms which simplify the diagnosis. Occasionally, as will be described in the following case report, multiple, acute, unrelated surgical conditions exist simultaneously and such cases essentially test the efficiency of the hospital staff.

Case Report—T. McT., male, white, age 26, was admitted to Knickerbocker Hospital, April 17, 1939, at 8 P. M. He stated that he had been suffering from severe, cramp-like abdominal pain for the past 36 hours. One year ago he had a similar attack, which was not so severe and subsided spontaneously. Otherwise, he had always been healthy. Just prior to admission, following a dose of castor oil, his bowels moved profusely. There was no nausea or vomiting and no urinary disturbance. Family and past histories were irrelevant.

Physical Examination—The patient looked acutely ill, and insisted on lying in a flexed position upon his right side. Pulse 144, temperature 103° F, respiration 36. Percussion note in the left chest was abnormal, hyperresonant at the apex with dullness at the base. Auscultation of the left chest disclosed distant breath sounds, with an occasional borborygmus. The abdomen was silent, scaphoid in shape, and had a board-like rigidity which precluded palpation of abdominal viscera. There was a tympanic note in the epigastrium, with dullness in the suprapubic region. Bones, joints, skin and reflexes were normal. Blood pressure 115/50. Blood count showed 23,400 white blood cells, 82 per cent polymorphonuclear.

The ambulance surgeon had made a tentative diagnosis of ruptured gastric ulcer. The visiting surgeon, Dr. C. Joseph Delaney, while admitting that the patient was acutely ill, did not believe his physical condition in keeping with a diagnosis of ruptured ulcer 36 hours previously. (The patient was very definite about the history.) This observation, plus the peculiar findings in the left chest, led to a "scouting" roentgenologic examination of the chest. The plain film showed shadows suggestive of gas pockets above the diaphragm, which led, in turn, to the administration of a barium enema. The roentgenologic report by Dr. Irving Schwartz states: "Examination by barium enema method outlined the colon, which was seen to pass through an aperture in the diaphragm. The diameter of the viscus was reduced at this point. The colon ascended into the left chest cavity to the level of the fourth rib posteriorly. Only after an attempt at evacuation could any barium be seen in the proximal colon." *Roentgenologic Diagnosis*: Diaphragmatic hernia with partial intestinal obstruction."

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The fact that a definite diagnosis of diaphragmatic hernia was made did not explain the apparent abdominal catastrophe. Various possibilities were considered. A perforated ulcer of the stomach could not be excluded, nor could peritonitis from other causes, such as appendiceal abscess. This being a male patient, at least the pelvic organs did not have to be considered. Torsion of the pedicle of the spleen was mentioned only as a possibility. The rigid abdominal wall, precluding the palpation of any localizing mass, made definite diagnosis impossible. The urgency of the peritoneal condition made an abdominal approach necessary. An apt question by the house surgeon, concerning the type of incision indicated, provoked considerable discussion. The site of the incision was delayed until the patient became anesthetized. As the anesthetic deepened, abdominal palpation was made to determine where the greatest delay in relaxation occurred. It soon became evident that the lower abdomen was the site of the lesion and, to our surprise, as the abdominal wall relaxed a definite suprapubic mass could be palpated.

Although the patient had voided just before coming to the operating room, he had not been catheterized and this suprapubic mass suggested an overdistended bladder. Catheterization proved this was not the case. With a definite, hard, nonmovable mass in the suprapubic area extending into the right gutter, an exploratory McBurney incision was made. Before the peritoneum was incised finger palpation detected the splenic notch. The incision was completed, and a definite diagnosis of wandering spleen was made. There was a moderate amount of nonodorous, serosanguineous free fluid in the peritoneal cavity.

Considering the left diaphragmatic hernia, the indications were evident. A six-inch upper left rectus incision was made. The upper lateral portion of the muscle was divided transversely, giving an excellent exposure of the abdominal cavity. The stomach and gallbladder were in normal position. The cecum was at the level of the umbilicus. The sigmoid could be seen in the left gutter passing through the gap of Bochdalek, as did all the small intestines and transverse colon.

The spleen was easily delivered from the pelvis through the rectus incision. Its pedicle was 12 inches long, one and one-half inches in diameter and the splenic vein was thrombosed. There were no adhesions. It had 12 clockwise turns. The pedicle could be traced up to its base in the lesser peritoneal sac at the site of the pancreas. An anomalous condition was then noted. The greater curvature of the stomach was entirely free. There was no gastrocolic omentum. It was obvious that the tail of the pancreas formed part of the base of the pedicle. It, however, was involved in the torsion, so no effort was made to dissect it free. A mass ligature was placed about the proximal end of the pedicle and the spleen with its pedicle was removed. Examination revealed that an elongated tail of the pancreas had been cut away. This stump was then reperitonized.

The diaphragmatic hernia was now considered. The gap was filled with large intestines and mesentery, and it was obvious that much time would be lost if an attempt were made to deliver this enormous mass of abdominal viscera through the relatively small aperture, even though a tube were inserted through the ring allowing air to enter and reduce the negative chest pressure. Therefore, a three-inch, vertical diaphragmatic incision was made, which permitted reduction *en masse* of the chest-contained viscera without disturbing the anesthetist, Dr. George H. van Gilluwe, as he was employing pressure anesthesia. One-third of the small intestines was blue and congested, due to one complete clockwise turn of the mesentery. After delivery of the intestines from the chest cavity, the entire mass, after detorsion, was completely encased in hot saline laparotomy pads and towels and left on the abdominal wall. This made it possible to readily reinspect the intestines and also made an excellent exposure of the hernial orifice, facilitating its repair. The vertical incision in the diaphragm was repaired and the gap was then obliterated by suturing the edge of the diaphragm to its normal attachments. The repair suture line was reinforced by overlapping it with perinephritic fascia, as described by Weinberg²⁴. When the packs were removed the intestines were found to be normal in color and no mesenteric thrombosis was evident. It was obvious that to place the intestines in so small a peritoneal

cavity would be difficult. The one redeeming feature was the fact that a large spleen had been removed. The patient being under deep narcosis, this was accomplished. However, fear of postoperative distention, with its lethal potentialities when intestines are crowded into a shrunken abdominal cavity, had to be taken into consideration. Since the original McBurney incision had not been closed, a cecostomy was performed, which provided a gas fistula. It was impossible to close the rectus incision by layer sutures, so through-and-through silkworm gut sutures were used, just approximating the wound edges. As a further means of preventing intestinal distention, or rather to help deflate if it occurred, the rectal sphincter was dilated to a point of partial paresis.

The patient, now in moderate surgical shock, after a two-hour operation, was returned to a warm bed over which an oxygen tent had been placed. His pulse rate was 120, or 24 less than on admission to the hospital. It remained below the high point during his entire

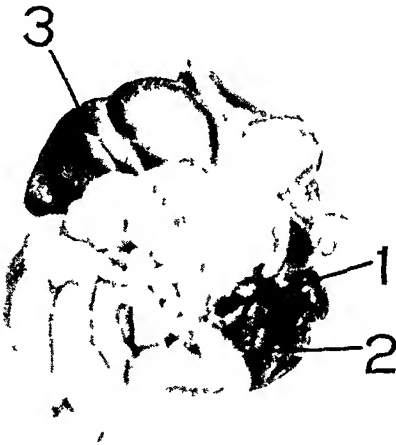


FIG 1—(1) Aperture in diaphragm (2) Gangrenous intestines (3) Liver

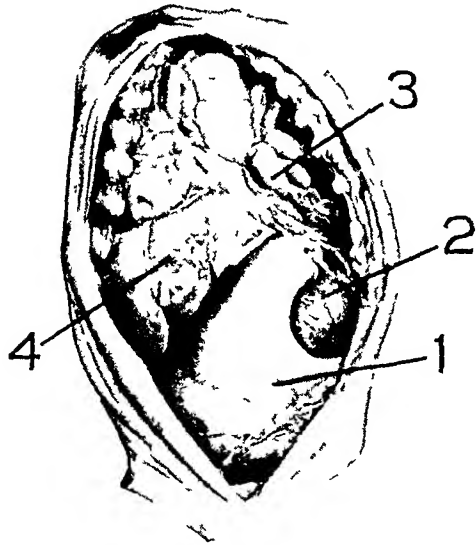


FIG 2—(1) Dilated stomach (2) Spleen (3) Intestines some of which are gangrenous above the diaphragm (4) Liver

convalescent period. A Levine tube was immediately inserted into the stomach and connected to a Wangenstein suction apparatus, and the gas fistula tube connected with a drainage bottle. It was necessary to prevent any intestinal distention.

Convalescence—Twelve hours later, largely from curiosity, a portable chest roentgenogram was made. As was expected, it disclosed a left pneumothorax with almost complete collapse of the left lung. In addition, it gave evidence, confirmed by physical findings, of a small area of pneumonia in the right lung. Medical consultation with Dr Arthur F Kraetzer was immediately secured. Sputum examination showed a Type XI pneumococcus. The patient was given sulfapyridine in adequate dosage and the congestion miraculously disappeared. Left pleural effusion developed but it, also, gradually disappeared with reexpansion of the left lung. Silkworm retention sutures were removed, as indicated by skin irritation, from the fourth to the sixth day. The abdominal wound healed *per primam*. The cecal tube was removed on the fourth postoperative day and the gas fistula closed spontaneously. From this time on, convalescence was slow but uneventful. The postoperative blood picture showed a gradual reduction in white blood cells, with a return to normal in the differential count.

On August 31, 1939, the patient was examined fluoroscopically after a barium meal had progressed to the colon. The left diaphragmatic movement was somewhat limited. The stomach was in normal position. He stated that he felt perfectly well and was able

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to work. Blood count at that time was Red cells, 3,950,000, white cells 8,300, neutrophils 76 per cent, lymphocytes 22 per cent, eosinophils 1 per cent, large monocytes 1 per cent, hemoglobin 78 per cent, platelets 336,700. It is recognized that this is too short a post-operative period to definitely exclude a recurrence of the diaphragmatic hernia or the possibilities of an abdominal incisional hernia, but the interest of the case and the unusual complication justify its being recorded.

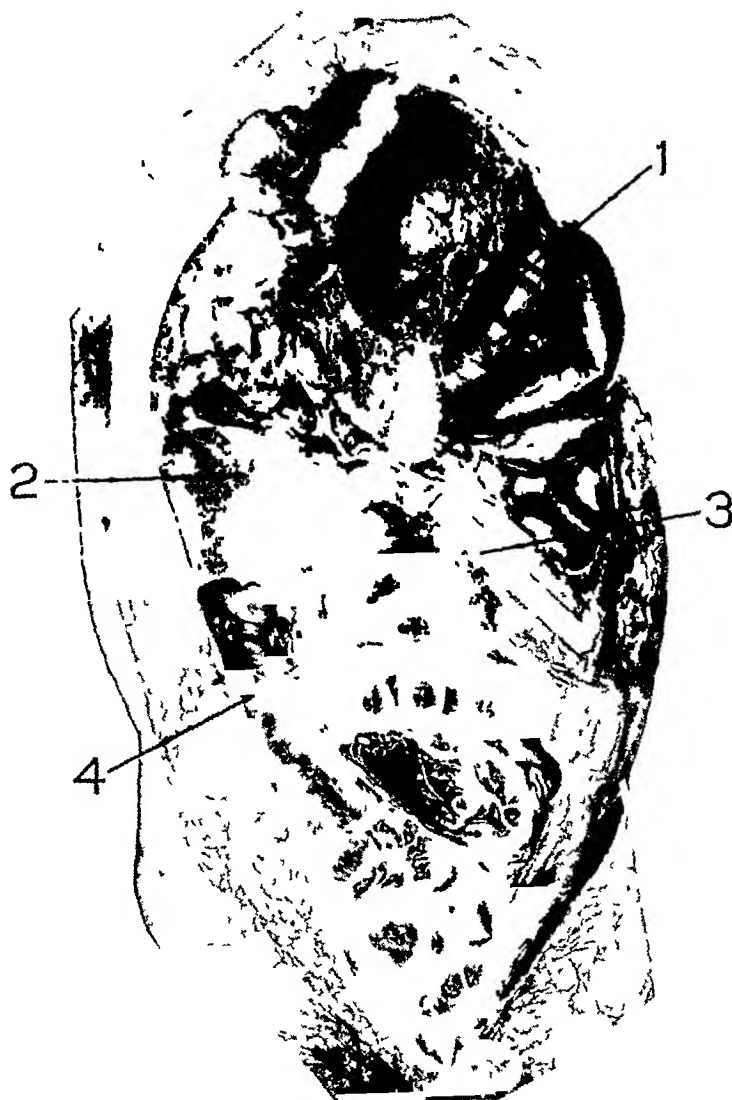


FIG 3—(1) Gangrenous intestines above the diaphragm (2) Liver (3) Diaphragm (4) Gangrenous intestines remaining in abdomen

Pathologic Examination—*Gross* Dr Henry Hoin The specimen is a surgically removed spleen and pedicle weighing 950 Gm. The serosa is smooth and glistening. There are several areas beneath the capsule which appear dark red and stand out from the remainder of the spleen, which is grayish-pink. These areas measure 3.5 cm in diameter. The pedicle is markedly edematous. On opening the splenic vein there is seen a loosely adherent thrombus occupying the entire lumen. The splenic artery is patent. On section, the organ cuts with increased resistance, leaving a dark red, meaty-appearing surface. The trabecular markings are decreased. The follicles cannot be made out. The pulp scrapes more readily than normal. There is also an irregular portion of tissue which is pancreas and which on section appears grossly normal. There is an accessory spleen 1.7 x 1 cm. *Microscopically*, the sections show severe passive congestion and edema of the spleen with multiple foci of recent hemorrhages and formation of sub-

capsular hematomata The tail of the pancreas shows marked chronic interstitial inflammatory change, compression atrophy and invasion of adjacent acini by connective tissue

To emphasize the fact that strangulation of the intestines frequently does occur in connection with diaphragmatic hernia, and for that reason if for no other, surgical repair is indicated, the photographs of three such strangulated cases, observed at autopsy, are included with this report (Figs 1, 2 and 3)

In 1933, Abell¹ collected and presented to the American Surgical Society all recorded cases of wandering spleen with torsion of the pedicle, adding two cases of his own This article furnishes valuable statistical information and reviews the various etiologic theories advanced by previous writers Since Abell's paper, numerous articles have appeared Most of the recent ones have case reports, with quotations from Abell's classic presentation A careful search of the literature reveals 20 reported cases since 1933 Since the addition of these cases does not materially change the statistics presented by Abell, they are cited by giving a short synopsis of them without attempting to incorporate them in the various tables compiled by him

REPORT OF 20 CASES OF TORSION OF A WANDERING SPLEEN
From the Literature Since 1933

Case 1⁵—A female, colored, age 22, had had three spontaneous labors and one early miscarriage Sixteen months previous to admission to hospital she had noticed a nonsensitive mass in the lower abdomen Three weeks prior to admission she had constant abdominal pain and vomiting, which lasted three days On the night before admission and five days before her regular menstrual period, she had considerable uterine hemorrhage At the time of admission she was acutely ill with severe pain, tenderness and a large mass in the lower abdomen Examination revealed a very sensitive mass 6.7 inches in diameter in the middle of the lower abdomen The upper border was at the umbilicus and the top felt like the edge of the liver Bimanually the mass was revealed above and in front of the uterus Pulse 103, temperature 103° F Blood count Three leukocyte counts average 8,000 polymorphonuclears 80 per cent, red cells 3,600,000 *Clinical Impression* Ovarian cyst or pedunculated myoma of the uterus with twisted pedicle

Operation—The spleen presented immediately under the abdominal incision It was deeply congested 7.5 x 4 inches in size with its upper border at the umbilicus Pedicle eight inches long with seven complete turns Marked ptosis of the stomach and transverse colon Splenectomy Blood count, ten days postoperative Red cells 4,300,000, white cells 9,400, hemoglobin 85 per cent polymorphonuclears 65 per cent lymphocytes 34 per cent transitionals 1 per cent

Result—Recovery

Case 2⁶—Female, age 50, mental patient Complained of pain in abdomen two days before admission to the hospital Examination revealed a swelling in the midportion of the abdomen No definite diagnosis could be made Pulse 120 temperature 100.4° F

Operation—Right paramedian subumbilical incision Ten ounces of blood removed There was a fracture of the spleen two inches long and one quarter inch deep Spleen was adherent to other viscera and had three and one half counterclockwise twists of the pedicle Splenic vessels were thrombosed and spleen was four times its normal size Splenectomy No weight given

Result—Recovery

Case 3⁴—Female, age 24, Chinese, one child She complained of enlargement of abdomen with pain First noticed this enlargement seven months previous to admission to hospital when she had an attack of epigastric pain nausea vomiting chills and fever Several mild attacks followed the first one and two weeks before admission she had a severe pain in the lower abdomen Not constipated She gave a history of malaria ten and 12 years before Examination negative except for abdomen Pulse 132, temperature normal Blood pressure 118/100 Blood count Red cells 4,360,000 white cells 18,600 hemoglobin 75 per cent polymorphonuclears 85 per cent *Preoperative Diagnosis* Ovarian cyst with twisted pedicle

Operation—There was a large spleen filling the pelvis, extending to the right median line and costal margin Splenectomy Weight of spleen 3,700 Gm *Postoperative Diagnosis* Wandering spleen with two and one half turns of the pedicle

Result—Recovery

Case 4²¹—Female, age 20 She complained of pain in the epigastrium transmitted to left side and thorax Temperature normal History of malaria After 13 days in the hospital the pain disappeared The abdomen was not painful and the tumor in the right iliac fossa close to Poupert's ligament was thought to be a kidney It was movable and slightly painful Vaginal examination not made Blood count normal Roentgenologic examination showed a ptosis of the intestines Fifteen days after ad

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mission the mass moved to the epigastric region, was more movable but not painful Four days later it wandered into right iliac fossa

Operation—Three weeks after admission Subumbilical celiotomy An ectopic spleen four times its normal size presented It was normal in color and consistency, no adhesions present The pedicle was long and rotated one quarter circle clockwise There were three supernumerary spleens Splenectomy Spleen weighed 400 Gm An increased white blood count gradually decreased to normal

Result—Recovery

Case 5²—Male, age 25, complained of colicky pains in abdomen and frequent eructations of gas Standing and walking exaggerated the pain Admitted to hospital for observation Examination showed a well developed and well nourished male There was a mass in the left lower quadrant, tenderness and muscular rigidity Pulse 90, temperature 100° F Blood count Red cells 4,750,000, white cells 9,850, hemoglobin 87 per cent, polymorphonuclears 60 per cent

Operation—Left rectus incision The spleen lay in the left lower quadrant Pedicle twisted three quarters time Splenectomy Spleen weighed 575 Gm

Result—Convalescence was complicated by thrombosis of the right femoral vein The blood count showed a marked increase in platelets, the lowest count being 448,000 on the eighth day, when thrombosis occurred Patient recovered

Case 6⁷—Female, age 68, uniparous Patient very sick and emaciated Known to have had a wandering spleen for five years, which, apparently, caused much distention, vomiting and pain On admission to hospital she had constant vomiting, marked distention and colicky pain Examination revealed a tumor above the pubis and extending to the umbilicus This was thought to be an ovarian cyst

Operation—The spleen contained a cavernous hemangioma The splenic vein was thrombotic The tail of the pancreas was found in the pedicle, which rotated through two circles Splenectomy Weight of spleen, length of pedicle and condition and disposition of pancreas not mentioned

Result—Recovery

Case 7¹⁶—Male, age 28 Twenty four hours prior to admission to the hospital patient had an attack of abdominal pain and vomiting Twelve months before he had a similar attack of pain, with fever, which lasted for 24 hours Examination revealed a tense, elastic, movable mass in the midline between the umbilicus and symphysis This mass was definitely tender but patient complained of greater tenderness over McBurney's point Temperature 40.3° C, pulse 120 There was no history of trauma, no trouble with micturition or defecation and no rigidity *Preoperative Diagnosis* Acute appendicitis

Operation—McBurney incision Small amount of turbid fluid in the abdomen The appendix was adherent to the posterior wall, thick and swollen It was removed intact The visible mesenteric veins were very large and distended The spleen was enlarged and in an unusual position A second incision was made in the midline below the umbilicus and disclosed a large, solid, cyanotic spleen, with the lower part down at the bottom of the pericetral fossa There was a long, vascular pedicle, which was twisted once around clockwise Removal of the spleen seemed unnecessary as the temperature, apparently, resulted from a gangrenous appendix However, due to the unusual position of the spleen, it was removed Weight 400 Gm Postoperative blood count Red cells 5,190,000, white cells 10,900, hemoglobin 98 per cent, neutrophils 86 per cent, large lymphocytes 8 per cent, small lymphocytes 2 per cent, transitionals 4 per cent Blood count on twenty second postoperative day Red cells 4,860,000, white cells 7,700 hemoglobin 85 per cent, neutrophils 55 per cent, eosinophils 2 per cent, large lymphocytes 24 per cent, small lymphocytes 14 per cent, transitionals 5 per cent

Result—Recovery

Case 8¹⁷—Male, age 34 History of malaria ten years previously, which lasted two years He was aware of an enlarged spleen but competed in athletic contests before and after having had malaria and had never noticed any pain Three days prior to admission to the hospital he had sharp, cramplike pains in the epigastrium, which spread to the entire abdomen He vomited and was unable to pass flatus Examination revealed an undernourished man, suffering greatly Pulse 30 Urine scanty The abdomen was rigid, painful to palpation, tympanitic and the splenic area appeared empty *Provisional Diagnosis* Wandering spleen

Operation—Abdominal cavity contained serosanguineous fluid The mass in the center of the abdominal cavity was black in color and bound by wide adhesions to the left colon The pedicle of the spleen was twisted two times counterclockwise Pedicle veins and arteries were thrombosed Splenectomy The spleen weighed 3 Kg and its maximum diameter was 25 cm

Result—Recovery

Case 9¹⁷—Female, age 45, six children Patient was in perfect health until seven years ago, when she developed malaria of the tertian type She had had no malarial fever for the past two years From the first year of the malarial infection she noticed a movable mass in her abdomen about the size of two fists Three years ago the mass began to grow noticeably She had indigestion, gastric disturbance and constipation Six days previous to admission to the hospital she was awakened with acute abdominal pain The pain continued the following day with vomiting, distention and no passage of gas from the rectum She became progressively worse, with some relief two days later when she had diarrhea The vomiting continued Examination on admission revealed an undernourished woman Pulse 120, temperature 38.5° C, respiration rapid The abdomen was distended, urine scanty There were spasms around the palpable mass, which was rounded, painful and not movable Vaginal examination revealed an ante flexed uterus The mass appeared to rest upon the uterus and seemed to be connected with the right parametrium *Preoperative Diagnosis* Ovarian cyst with twisted pedicle

Operation—There was a small amount of serous fluid in the abdominal cavity, which was occupied by a large mass, which was recognized as a greatly enlarged, ptosed spleen. There were no adhesions. The pedicle was long, thick and tortuous and had four counterclockwise twists. The pedicle pulled on the mesocolon and the first part of the jejunum. The stomach and duodenum were dilated. Splenectomy. The spleen weighed 2 Kg., was 25 cm. in its greatest diameter, and the pedicle was 12 cm. long.

Result—Recovery

Case 10 11—Female, age 21. Family and previous history irrelevant. She had given birth to a normal child four months previous to admission, and since that time had had pain in the abdomen localized in the lower quadrant. Pain more intense when she moved around. Ten days before admission to the hospital the pains increased and extended throughout the entire abdomen. She was nauseated but did not vomit. Bowel movement with enema was efficacious. Examination revealed abdominal rigidity and a tumor the size of a fetal head below the umbilicus. It was fixed, painful and irregular, with tympany around the mass. Temperature 37.6° C., pulse 95, respiration normal. Pelvic examination was normal.

Operation—Median suprapubic incision. Free serous fluid was observed when the peritoneum was opened. An ectopic spleen was found in the lower abdomen with the pedicle showing two complete twists. After removal of the spleen it was found to contain a round, partially calcified tumor, which was approximately one third of the removed splenic tissue. Spleen and tumor weighed 650 Gm.

Result—Recovery

Case 11 15—Female, age 50. For ten years she had suffered from pain in the left iliac fossa, with a heavy, twisting sensation in the lower abdomen. For past several months pain became more severe with vomiting and chronic indigestion. She often had dizzy spells, belched gas, was distended and constipated. Examination revealed marked abdominal distention. There was a round, hard, movable tumor the size of a fetal head in the epigastrium. *Provisional Diagnosis* Uterine fibroids with cancer of the colon.

Operation—Midline suprapubic incision. The tumor presented in the pelvis and was easily identified as an incarcerated spleen. The pedicle was twisted three quarters of a circle and was thickened. The splenic vein was the size of a normal jugular and the splenic artery pulsated. The tail of the pancreas formed part of the base of the pedicle and was involved in the torsion. The pedicle compressed the transverse colon. Weight and size of spleen not given.

Result—Recovery

Case 12 20—Male, age 10. Past history irrelevant. Ten days before admission to the hospital he had cramp like pains in the abdomen with nausea and vomiting. These subsided in 24 hours for three days. Two days before admission to hospital pain recurred in left upper quadrant. Examination revealed a well nourished boy. Blood pressure 98/68, pulse 100, respiration 22. Examination negative except for a smooth, painless mass in left upper quadrant, extending one inch below the umbilicus. *Clinical Diagnosis* Wandering spleen.

Operation—High midline incision. Spleen enlarged about six times. Two complete rotations of the pedicle, which was six inches long and contained thrombosed veins. Blood count: Red cells 3,780,000, white cells 5,950, hemoglobin 62 per cent, polymorphonuclears 50 per cent, lymphocytes 44 per cent, platelets 155,000.

Result—Recovery

Case 13 18—Male, age eight. Never a robust child. Frequent headaches with stomach pains. At two years of age had an attack of acute abdominal pain. Two years before admission to hospital he had a similar attack. Attack of pain, nausea and vomiting four days prior to admission. Examination revealed an undernourished boy. Temperature 98.8° F., pulse 128, respiration 26. Generalized abdominal pain but more tender in right lower quadrant. Abdomen markedly distended, rigid, and no tumor mass was palpable. Patient treated conservatively and distention subsided. A tumor could then be felt 3 cm. to left of umbilicus across to the anterior superior spine in the right ilium. Blood count: White cells 13,800, polymorphonuclears 88 per cent. *Provisional Diagnosis* Ruptured appendix.

Operation—Right rectus incision. Intestines were red and distended. Considerable amount of bloody fluid in the peritoneal cavity. Spleen three times its normal size with three twists of the long pedicle. The tail of the pancreas was involved with both the artery and vein thrombotic. Postoperative blood count: Red cells 3,400,000, white cells 9,200, hemoglobin 65 per cent, polymorphonuclears 49 per cent.

Result—Recovery

Case 14 23—Female, age eight. Normally developed child. She had symptoms of pain, with nausea and vomiting two days before admission to the hospital. On admission, the temperature was 101.4° F., pulse 120, respiration 24. White blood count was 24,000.

Operation—Splenectomy. The pedicle was long with three complete clockwise turns. Veins were thrombosed. The spleen weighed 425 Gm. Postoperative complication—evisceration after one week.

Result—Recovery

Case 15 8—Female, age 39. Abortion at age 16. After this illness she felt pain in the left iliac fossa. This pain became habitual, was colicky in character and was accompanied with vomiting. Abdomen began to increase in size. A second attack occurred after a pregnancy with abortion at six months. The pain became constant and tumor continued to increase in size. Examination revealed a well nourished woman of masculine type. A tumor could be felt filling the entire left side of abdomen. It was hard, painful and fixed. Vaginal examination revealed an anteverted uterus. The tumor could be felt bimanually. *Clinical Diagnosis* Ovarian cyst.

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Operation—Median incision below umbilicus A considerable quantity of fluid found in the peritoneal cavity A large spleen presented, and it was necessary to increase the incision 3 cm, to the edge of the umbilicus The spleen was violet in color with one complete twist of the pedicle clockwise The pedicle was necrotic and included the tail of the pancreas It was adherent to the intestines Splenectomy Weight of spleen 2,800 Gm Preoperative blood count Granulocytes 55 per cent, lymphocytes 29 per cent, plasmocytes 0.4 per cent, monocytes 14 per cent Postoperative blood count Red cells 4,168,000, hemoglobin 70 per cent, leukocytes 8,725, granulocytes 75 per cent, lymphocytes 15 per cent, monocytes 9.25 per cent

Result—Recovery

Case 16⁹—Female, age 23 Previous history negative She had a sudden, severe, colicky abdominal pain accompanied by metrorrhagia Just before this attack she had passed through a normal pregnancy except for slow engagement of the head during first stage of labor Vaginal examination revealed an oval, tender mass in culdesac of Douglas, to left of median line *Clinical Diagnosis* Ovarian cyst with twisted pedicle

Operation—Incision not mentioned A large spleen presented with a three fold torsion of the pedicle Splenectomy Spleen weighed 225 Gm 14x9x5 cm in size The pedicle was the size of a finger and passed in front of the transverse colon and around the greater curvature

Result—Recovery

Case 17¹⁰—Female, age 31, two children Three days prior to admission to hospital patient picked up her child and since then had periodic, acute attacks of pain in left upper quadrant No history of malaria Typhoid years ago Examination revealed a poorly nourished female Abdomen was greatly distended and the left upper quadrant was the site of a swelling parallel to the rib line, which was elastic, easily movable, round and about the size of the spleen

Operation—Midline incision from xiphoid to umbilicus The spleen presented It was enlarged to twice its size and cyanotic The pedicle was twisted from 130° to 150°, left to right It was attached at the upper pole to the lower portion of the stomach by adhesions, which caused the twisted pedicle There being no pathologic changes, fixation of the spleen was decided upon

Result—Recovery

Case 18³—Male, age 30 History irrelevant Patient noticed a tumor in the right lower quadrant No pain or vomiting No history of malaria Examination revealed an increase in size of the abdomen, especially in the right lower quadrant Temperature normal *Clinical Diagnosis* Acute appendicitis

Operation—McBurney incision There were adhesions about a bluish tumor, which proved to be the spleen with moderate degree of torsion Splenectomy Weight of spleen 420 Gm

Result—Recovery

Case 19¹⁴—Female, age 25, two children Patient suffered from abdominal pain one week previous to examination States she was two months pregnant, and that before pain started she had fallen upon her side on a sharp rock She had suffered from malaria for a year without treatment Examination revealed a large, hard, painful tumor in left side of abdomen

Operation—Since all symptoms pointed toward a visceral injury, an exploratory incision was made, under local anesthesia, in the left iliac fossa The tumor proved to be a ruptured spleen This incision was closed and a median incision made Two deep fissures were revealed on the anterior surface of the spleen with torsion of the pedicle until it was upside down Splenectomy Weight of spleen 1,550 Gm It was 23 cm long by 16 cm in diameter

Result—Not mentioned

Case 20²⁵—Female, age 33 Three normal deliveries Five months pregnant at time of present attack Complained of pain in abdomen with distention, nausea and vomiting for two and one half hours before admission No history of previous attacks No history of typhoid fever or malaria, no previous operations Examination revealed a markedly distended abdomen Thickening of intestines felt on palpation Dulness extending to right upper quadrant Pelvic examination revealed a uterus size of five months' pregnancy

Operation—Midline incision from xiphoid to 4 cm below the umbilicus About 800 cc of serous fluid present in abdominal cavity The spleen was in the ileocecal region of the abdominal cavity Spleen congested, thick, cyanotic, and was easy to deliver The pedicle was twisted three times and the stomach was turned completely about Spleen returned to normal color and size after detorsion, and the stomach began a slow evacuation after return to its normal position

Result—Stormy convalescence due to pneumonia and pregnancy Complete recovery

The history of diaphragmatic hernia is intensely interesting Although its first recognition dates back to 1610, when Ambroise Paré recorded two cases of traumatic origin, no particular interest was shown until comparatively recent times Hedblom¹³ collected 1,435 cases from the literature in 1931, and made an effort to convince the medical fraternity of its frequency and its dangerous potentialities Since that time Harrington,¹² Tuesdale,²² and many others have published papers demonstrating its operability and the wis-

dom of having such defects repaired before an acute surgical catastrophe occurs. It is to be regretted, however, that regardless of the splendid work that has been done, many physicians still recommend "watchful waiting" treatment for such patients. This advice is particularly vicious when given young patients who suffer from congenital and acquired diaphragmatic hernia. It is readily admitted that a few people have lived their normal longevity regardless of having had a diaphragmatic hernia. It must likewise be admitted that most people suffering from such a handicap incur material risk in not having it corrected. The following case history is illustrative.

Case Report—A child of 18 months was admitted to a metropolitan hospital for a medical ailment. During the course of examination a diagnosis of an asymptomatic diaphragmatic hernia was made. The mother was not warned concerning the existence of this hernia. Three months later a strangulation occurred, and, at autopsy, gangrenous intestines were found above the diaphragm. This patient could have been operated upon prior to strangulation with minimal risk.

Harrington's¹² publications offer a very satisfactory classification of diaphragmatic hernia. He has recently reported 131 cases diagnosed at the Mayo Clinic. He advocates the abdominal approach in all peri-esophageal herniae, while Truesdale,²² who has also had a large experience, believes most diaphragmatic herniae are best operated upon from a thoracic approach. The combined approach advocated by some surgeons certainly has a mechanical advantage, but it usually is not necessary. Donovan,¹⁰ who reported ten cases of congenital diaphragmatic herniae in infants, is well satisfied with the abdominal approach. He forcibly calls attention to the dangers of delayed surgical treatment. The writer, basing his judgment on a modest experience, prefers the abdominal approach for peri-esophageal herniae but the thoracic approach for the other more common types, such as those of traumatic origin, or those through the gap of Bochdalek. It is admitted, however, that the abdominal approach in the case herewith reported, which was from necessity rather than from choice, was most satisfactory.

In general, either route has its advantages, and most cases are best operated upon by the approach with which the particular surgeon is more familiar. If, however, dense adhesions have formed, which is often the case in large congenital herniae in children, certainly, the thoracic approach is to be preferred. In one case of diaphragmatic hernia a diagnosis of absence of adhesions was made by introducing barium into the colon and also inducing a pneumothorax. When the child was in the erect position no viscera could be seen in the chest, when the head was down the left pleural cavity became filled with intestines and there was a pneumoperitoneum. This patient, a boy, age 10, was operated upon by the thoracic route. Reduction of the viscera into the abdomen was easily accomplished, but when held there in the very contracted peritoneal cavity, the patient stopped breathing. Releasing the intestines reestablished breathing. For this reason the hernia was not repaired. Donovan¹⁰ notes this condition in one of his cases and cites it as an argument against delay in operative treatment.

In the present case, naturally the advisability of concurrently reducing and repairing the diaphragmatic hernia, following the removal of a wandering spleen with pedicle torsion, became a real question of surgical judgment. Admittedly, the first procedure was a major operation for an acutely sick patient to withstand. But, knowing the latent possibilities, as cited above, of delay in treating diaphragmatic hernia, there was no hesitation. The findings and the result fortunately justified the decision.

BIBLIOGRAPHY

- ¹ Abell, I. Wandering Spleen with Torsion of the Pedicle. *ANNALS OF SURGERY*, 98, 722-735, October, 1933.
- ² Adkins, E. H. Ptosed Spleen with Torsion of Pedicle. *ANNALS OF SURGERY*, 107, 832-835, May, 1938.
- ³ Biondo, A. Migration of Spleen with Twisted Pedicle into the Right Iliac Fossa Associated with Acute Appendicular Syndrome. *Il Policlinico*, 41, 650-656, April 30, 1934.
- ⁴ Branch, J. R. B. Splenomegaly (Malarial) with Torsion of Pedicle. *Chinese Med Jour*, 49, 475-476, May, 1935.
- ⁵ Bullard, E. A. Pelvic Spleen with Torsion of Pedicle. *Amer Jour Obstet and Gynec*, 25, 599, April, 1933.
- ⁶ Contin, Y. Torsion of Spleen. *Lancet*, 2, 1175, 1935.
- ⁷ Dawson, J. B. Wandering Spleen Containing Large Cavernous Hemangioma with Torsion of Pedicle. *New Zealand Med Jour*, 36, 393-394, 1937.
- ⁸ de Carvalho, R. V., and de Azevedo, G. V. Ectopic Spleen with Syndrome of Acute Torsion. *Rev de cir de São Paulo*, 1, 81-92, August, 1934.
- ⁹ Desplas, B. Ectopic Malarial Spleen with Twisted Pedicle Diagnosed as Ovarian Cyst with Twisted Pedicle. Recovery after Splenectomy. *Bull et mém Soc Nat de chir*, 61, 985-988, July 20, 1935.
- ¹⁰ Donovan, E. J. Congenital Diaphragmatic Hernia. *ANNALS OF SURGERY*, 108, 374-388, September, 1938.
- ¹¹ Gallo, A. G., *et al*. Cholesterol Cyst in Spleen with Twisted Pedicle, Splenectomy Case. *Bol y trab de la Soc de cir de Buenos Aires*, 16, 985-987, September 14, 1932.
- ¹² Harrington, S. W. Diaphragmatic Hernia. *Arch Surg*, 16, 386, 1928, Diaphragmatic Hernia. *J A M A*, 101, 987, September 23, 1933, Diaphragmatic Hernia. *Proc Staff Meet Mayo Clin*, 9, 251, April 25, 1934, Diaphragmatic Hernia. *Western Jour Surg*, 44, 255, 1936.
- ¹³ Hedblom, C. A. Diaphragmatic Hernia. *J A M A*, 85, 947, 1925, Diaphragmatic Hernia. *ANNALS OF SURGERY*, 94, 776, 1931, Diaphragmatic Hernia. *Ann Int Med*, 8, 156, 1934, Selective Surgical Treatment of Diaphragmatic Hernia. *Transactions Amer Surg Assoc*, 49, 448, 1931.
- ¹⁴ Kabbani, M. N. Traumatic Rupture of Malaria Splenomegaly with Torsion of Pedicle. *Rev prat d mal d pays chauds*, 15, 251-254, June, 1935.
- ¹⁵ Lamarque, P., *et al*. Gastric Volvulus and Colic Stenosis Secondary to Pelvic Ectopia of Spleen. *Arch d'electric Med*, 46, 107-115, May, 1938.
- ¹⁶ Linden, O. Operated Case of Splenic Torsion in a Male Patient. *Acta chir Scandinav*, 75, 68-72, 1934.
- ¹⁷ Mauro, M. Ectopic Malarial Spleen with Torsion of Pedicle Complicated by Mechanical Intestinal Occlusion (2 Cases). *Riforma med*, 50, 1153-1158, July 28, 1934.
- ¹⁸ Motley, J. C. Wandering Spleen with Torsion of Pedicle. *Virginia Med Monthly*, 62, 14-19, 1935.
- ¹⁹ Nikotin, M. P. Torsion of the Pedicle of an Ectopic Spleen. *Vestnik khir*, 44, 88-90, 1936.

- ²⁰ Percy, N M Twisted Pedicle of Wandering Spleen in Boy Ten Years of Age Surg Clin North Amer, 14, 971-975, 1934
- ²¹ Petridis, M Torsion and Ectopy of Spleen Taken for Ovarian Cyst Bull et mem Soc Nat de chir, 59, 1328-1330, November 18, 1933
- ²² Truesdale, P E Hernia of Diaphragm New England Med Jour, 212, 240, February, 1935, Hernia of Diaphragm Amer Jour Surg, 32, 204, June, 1936, Hernia of Diaphragm New England Med Jour, 213, 1159, December, 1935
- ²³ Truesdale, P E, and Freedman, D Wandering Spleen with Torsion of Pedicle Surgery, 4, 700-707, 1938
- ²⁴ Weinberg, J Diaphragmatic Hernia in Infants, Surgical Treatment with Use of Renal Fascia Surgery, 3, 78-86, January, 1938
- ²⁵ Zhdanovich, S N Volvulus of Stomach Caused by Torsion of Dislocated Spleen Vestnik khir, 34, 157-158, 1934

proven by positive smears. He points out that this relatively small number of patients was seen in regions where the malaria morbidity is quite high, and reasons that the problem of differential diagnosis between abdominal malaria and acute surgical conditions occurs rarely. Such a conclusion obviously may not be justified, since many such cases may not be seen and since there is no means of comparison with the total number of cases of malaria observed. In his observations, Taylor lays great stress upon the absence of involuntary abdominal rigidity as a means of distinction between acute abdominal malaria and acute surgical lesions. He also points out that 85 per cent of the total number of cases gave positive tests for occult blood in the vomitus or gastric contents, and states that this finding is of great value in establishing the diagnosis of abdominal malaria.

Ninety-three per cent of the patients in the series reported by Taylor were infected with aestivo-autumnal malaria, and in most of the previous reports of cases similar to these *Plasmodium falciparum* has been the causative organism.

In a recent article by Ochsner and Murray,⁶ malaria is mentioned as an occasional cause of abdominal pain and vomiting, and the following statements are made: "In our experience, acute abdominal manifestations occur most frequently in cases of malaria which have been incompletely treated. Of diagnostic importance are the relative leukopenia, absence of abdominal rigidity, and higher temperature than is usually seen in acute abdominal conditions."

No attempt is made here to review the literature on this subject. There are fairly frequent references to atypical forms of malaria in the European literature, particularly in Italy and France. It is doubtful, however, if in the United States malaria is usually considered in the differential diagnosis of the surgical diseases of the abdomen. The number of cases reported here indicates that this condition may occur fairly frequently in the Southern States.

In this group of nine cases, eight of the patients were selected from a total of 266 cases of malaria admitted to the Vanderbilt University Hospital during the last 13 years. The remaining patient was seen recently in another hospital. All of the patients were white, six were males, and four were females. The youngest patient was 15 years old, all the others being adults. All of the patients lived in rural sections except one, a student nurse at the Vanderbilt Hospital.

CASE REPORTS

Case 1—L. C., white, male, age 46, was admitted to the Surgical Service at Vanderbilt University Hospital August 31, 1932. For six weeks he had had headache, general malaise and had been troubled with epigastric discomfort and eructation which were aggravated by the taking of fatty foods and which were occasionally accompanied by slight fever. Five days before admission he had a chill, followed by a severe headache. Three days before admission he was seized with sudden severe pain in the right upper abdomen, followed quickly by nausea and repeated vomiting. The pain remained localized and continued until admission. There was no jaundice, diarrhea, or change in the char-

acter of the stools The past history revealed that a year and a half before admission, he had several chills, for which he was given quinine

Physical Examination—Temperature 104.8° F, pulse 128, respirations 28 The patient was well developed and well nourished, looked quite sick and was complaining bitterly of abdominal pain The chest was clear The abdomen was moderately distended, symmetrical, moved poorly with respiration There was moderate tenderness and muscle spasm in the right upper quadrant The liver edge was palpable slightly below the costal margin, and was smooth and slightly tender The spleen was not palpable and no masses or other viscera were felt The rectal examination was negative There was no jaundice

Red blood count 4,100,000, hemoglobin 12 Gm, white blood count 5,300 The urine contained three to four WBC and an occasional RBC per high power field in a centrifuged specimen

The diagnosis on admission was acute cholecystitis, and possibly empyema of the gallbladder Malaria was not suspected at this time, in spite of the leukopenia, and the routine blood smear was not examined until about four hours after admission This revealed numerous ring forms of *P. vivax* Quinine, 0.6 Gm tid, was started immediately and the symptoms disappeared quickly The temperature rose to 103.2° F on the day following admission but he had no chill The tenderness over the gallbladder region subsided rather slowly, persisting to a slight degree for six days His subsequent course was uneventful and cholecystograms were made before he was discharged from the hospital, the dye being administered intravenously These showed concentration of the dye in the gallbladder and no stones were seen The patient left the hospital 11 days after admission

He returned to the Out-Patient Department four and one-half years later complaining of indigestion, frequency of urination, nocturia and dysuria Two blood smears showed no parasites and gastro-intestinal roentgenologic examination was negative He was found to have a stricture of the urethra and with dilatations his symptoms were relieved

In this case the history of chills in the past and the leukopenia at the time of admission were the only things which might have suggested malaria before the parasites were found

Case 2—P W, white, male, age 28 was admitted to the Surgical Service September 17, 1932, with a history of onset of abdominal pain three weeks previously The pain was generalized, cramping in character and was associated with nausea and vomiting Four days after onset he was seen by his doctor, who found the abdomen to be slightly tender, and markedly distended throughout His diagnosis at that time was generalized peritonitis, possibly resulting from a perforation of the bowel The patient refused hospitalization, and was kept in bed and given large doses of morphine at frequent intervals The abdominal distention became progressively more marked and pain and occasional vomiting continued He had an irregular fever which ranged from 101° to 105° F, but he had no chills The past history was not remarkable He had typhoid fever eight years previously, had never had malaria

Physical Examination—Temperature 98° F, pulse 100, respirations 18 The patient was well developed and well nourished, looked moderately ill The skin was warm and dry The chest was clear The abdomen was distended and there was moderate diffuse tenderness, with a "doughy" sense of resistance to palpation, over the entire abdomen There were no masses and the liver and spleen were not palpable Rectal examination was negative, and the remainder of the general physical examination was not remarkable

Red blood count 4,200,000, hemoglobin 12 Gm, and white blood count 7,000 The urine was clear, NPN was 24 mg, and the blood smear was negative for parasites

Twelve hours after admission, the temperature rose to 102.6° F, then fell to normal

and remained there for two days. The impression during this time was uncertain, but the process was thought to be either tuberculous peritonitis or a subsiding, diffuse, acute peritonitis. On the third day, the white blood count was 4,650, and the temperature rose to 100.2° F. Blood smears and thick drop at this time revealed many crescents of *P. falciparum*. The patient was transferred to the Medical Service, and he was immediately started on atebryn, 0.1 Gm t.i.d. The symptoms and signs almost immediately disappeared and he was discharged from the hospital nine days after admission, in good condition.

In this case malaria was not suspected until the third day of admission when there was a leukopenia coincident with a rise in temperature. There was nothing in the history or physical examination which suggested malaria as the cause of the symptoms, and the correct diagnosis was made after observation of the patient's course in the hospital.

Case 3—J. T., white, female, age 22, entered Vanderbilt Hospital March 17, 1929, on the Medical Service. Five hours before admission she suddenly began to have severe pain in the epigastrium and in the region of the umbilicus, cramping in character, which was quickly followed by nausea and repeated vomiting. These symptoms persisted until admission. Three days before this she had a similar, less severe attack which lasted about eight hours. There had been no chills. The past history was unimportant.

Physical Examination—Temperature 98.6° F, pulse 84, respirations 20. The patient looked quite sick, was in marked pain, and vomited during the examination. The chest was clear. The abdomen was scaphoid, moved fairly well with respiration and was symmetrical. There was no visible peristalsis and audible peristalsis was normally present. There was moderate tenderness in the epigastrium and about the umbilicus, but there was no muscle spasm and no masses could be felt. The liver and spleen were not palpable. Pelvic and rectal examinations were negative and the remainder of the general physical examination revealed no abnormalities.

Red blood count 4,500,000, hemoglobin 12 Gm, white count 10,000. Routine blood smears were normal and showed no parasites. The urine was clear.

The diagnosis at this time was not clear, though partial intestinal obstruction and ureteral calculus were mentioned as possibilities. Because her symptoms continued, she was transferred to the Surgical Service a few hours after admission. During the next two days her symptoms varied in intensity, occurring in attacks which came on every few hours. The temperature remained normal, and on the third day, moderate tenderness in the region of the left kidney was noted. The kidney was not palpable and the urine was clear. She was cystoscoped, both ureters were catheterized and pyelogram of the left kidney was made, with negative results. Shortly after the cystoscopy she had a chill and her temperature rose to 104° F. Routine blood smear obtained at this time showed many forms of *P. vivax*. She was given quinine, 0.6 Gm, at once, and this was continued t.i.d. The temperature remained normal thereafter and all symptoms and physical signs rapidly disappeared. She left the hospital on March 30, 13 days after admission, in good condition.

In this case, the diagnosis was particularly difficult, and the parasites were found in a smear which was obtained as a part of the routine examination when the patient unexpectedly had a chill.

Case 4—M. M., white, female, age 15, was admitted to the Surgical Service of Vanderbilt Hospital March 12, 1930. For nine months she had had intermittent attacks of pain and soreness in the right lower quadrant and the right lumbar region. At the onset she had several chills at irregular intervals, but these stopped after a few weeks. About three months after the onset, she had rather marked dysuria and frequency of urination during an attack of pain, and these symptoms occasionally recurred with subsequent attacks. On one occasion she had hematuria.

The last attack began five days before admission with pain in the right lower abdomen, which continued without relief. She was nauseated and 48 hours before admission she vomited. There were no chills but she thought she had had some fever. The past history was of no importance.

Physical Examination—Temperature 99.8° F, pulse 94, respirations 22. The patient was well developed and well nourished, looked moderately ill. The chest was clear. The abdomen was scaphoid, symmetrical, and moved fairly well with respiration. There was moderate, well localized tenderness in the right lower quadrant and slight tenderness in the left lower quadrant. There was no muscle spasm and no masses were felt. The liver and spleen were not palpable. Pelvic examination revealed tenderness in both adnexal regions but no masses could be felt. There was no vaginal discharge. The remainder of the physical examination was essentially negative.

Red blood count 3,000,000, hemoglobin 9.2 Gm, white count 4,400. The urine contained only occasional white blood cells.

On admission it was thought that she had acute appendicitis or acute pyelonephritis. Because of the leukopenia, the routine blood smear was examined with great care, and a few forms of *P. vivax* were found. She was immediately started on quinine, 0.6 Gm tid, and the symptoms and physical signs quickly disappeared. She was discharged from the hospital four days after admission, in good condition.

Three and one-half years later, on September 24, 1933, she returned to the hospital with abdominal pain of three days' duration, accompanied by nausea and vomiting. Parasites were again found in the blood and with the administration of quinine, she rapidly recovered.

Case 5—J. A. J., white, male, age 34, was admitted to the Surgical Service May 19, 1935. Four days before admission he became nauseated, and shortly thereafter had a chill. He continued to feel badly and was nauseated until 14 hours before admission when he suddenly began to have severe, cramping pain in his upper abdomen. This was followed by repeated vomiting, and the pain soon became generalized through the abdomen. Shortly after the onset a fine rash appeared over the trunk. The abdominal pain continued until admission, but he had no more chills. The past history revealed no important information.

Physical Examination—Temperature 99.4° F, pulse 96, respirations 30. The patient was well developed and well nourished, looked moderately ill and was writhing with pain in the abdomen. The chest was clear. The abdomen was scaphoid and moved well with respiration. There was moderate tenderness around the umbilicus but no muscle spasm. No masses were felt and the liver and spleen were not palpable. Rectal examination was negative and nothing else of importance was found in the examination.

Red blood count 4,700,000, hemoglobin 15 Gm, white count 5,100. No parasites were found in the blood smear. The urine was clear.

The diagnosis was not clear. Because of the character of the onset of symptoms, food poisoning was suspected. About four hours after admission the temperature rose to 103.6° F, but he did not have a chill. Blood smears and thick drop at that time revealed many ring forms of *P. vivax*. No treatment was instituted at that time, however, and on the day following admission his symptoms were much less marked and the temperature remained normal. On the third day the temperature rose to 103.6° F and he had a chill. He was then given quinine 0.6 Gm tid, with prompt relief of all symptoms and disappearance of abdominal tenderness. He was discharged from the hospital two days later.

Malaria was thought of as a possibility here because of the leukopenia and the lack of an adequate explanation for his symptoms. A careful search of the blood smears was required before the parasites were found.

Case 6—E H, white, female, age 24, was admitted to the Medical Service September 9, 1932, with a history of onset of severe knife-like pain in the right lower quadrant of the abdomen four days previously. The pain radiated to the lower back and was accompanied by nausea and repeated vomiting. After the first day there was no nausea, but there was severe headache and backache, and two days before admission she had a chill. This was followed by a watery diarrhea which continued until admission, and by persistence of the pain in the right lower abdomen. She had had frequent dull headaches for two months prior to admission. There was no history of malaria in the past.

Physical Examination—Temperature 101° F, pulse 112, respirations 22. The chest was clear. The abdomen was scaphoid, symmetrical, and moved fairly well with respiration. There was moderate diffuse tenderness in the right lower quadrant and in the right upper quadrant under the costal margin, but no rigidity. The spleen and liver were not palpable and no masses were present. Pelvic examination revealed moderate tenderness in both adnexal regions. No masses were present. The physical examination was otherwise negative.

Red blood count 4,300,000, hemoglobin 11.5 Gm, white count 8,700. Smear of the blood was negative for parasites. The urine was clear except for occasional white cells.

It was thought on admission that she had an acute enteritis.

Her temperature fell and remained normal on the second day, but on the third day she had a severe chill and the temperature rose to 106° F. The abdominal pain became very severe at this time. The white blood count was 3,400, and blood smears and thick drops were obtained which showed many ring forms of *P. vivax*.

She was given atabrin 0.1 Gm tid. Her symptoms and physical signs rapidly disappeared and the temperature subsequently remained normal. She left the hospital in good condition on September 22, 13 days after admission.

She was seen again August 12, 1938, because of a nontoxic goiter which was becoming slowly larger. She had had no further attacks of abdominal pain and no symptoms suggesting malaria.

Case 7—M F, white, male, age 33, was admitted to the Surgical Service August 12, 1934. Four days before admission he began to have cramping epigastric pain which was soon followed by nausea and vomiting. These symptoms persisted until the time of admission. There was high fever but no chills and there was no history of previous similar attacks. The patient had had an appendectomy previously and had been given typhoid vaccine 10 years ago.

Physical Examination—Temperature 104.6° F, pulse 120, respirations 24. The patient was fairly well developed and well nourished. He looked quite sick and vomited several times during the examination. The chest was clear. The abdomen was symmetrical, moderately distended, and moved very slightly with respiration. There was moderate general tenderness, with fairly marked tenderness in the epigastrium. There was some resistance to palpation throughout the abdomen, with no localized areas of muscle spasm. No masses were felt and the liver and spleen were not palpable. The physical examination was otherwise not remarkable.

Red blood count 5,000,000, hemoglobin 13.5 Gm, white count 2,000. Because of the leukopenia the routine blood smears were examined very carefully, but no parasites were found. The urine examination was negative, the Widal and several stool examinations and cultures were negative and blood culture remained sterile.

The impression at the time of admission was typhoid fever, and malaria was mentioned as a possibility.

About 24 hours after admission a macular rash, which was generalized over the body, appeared. At this time the leukocyte count was 7,200. Smears of the blood were again examined with negative results. A thick drop was also obtained, however, and this showed ring forms of *P. falciparum*. The patient was transferred to the Medical Service and was immediately started on quinine 0.6 Gm tid. His temperature fell to

normal within 24 hours, and the symptoms subsided rapidly. He was discharged from the hospital nine days after admission.

Case 8—G. H., white, male, age 27, came to the Vanderbilt Hospital emergency room August 6, 1935, complaining of severe abdominal pain. Five days before this he began to have general malaise and headache. Three days before admission he was awakened at night with sudden, severe, knife-like pain in the right upper abdomen and the right flank, which soon became generalized and cramping in character. These symptoms continued without relief but varied in intensity. He was repeatedly nauseated but did not vomit. He had no chills but thought he had some fever. A few hours before admission he was seen by his family doctor who told him he had a ruptured appendix and advised him to go to the hospital.

The past history revealed that the patient had for several years lived in an unscreened house on a river bank. He had received typhoid vaccination three years previously and had always been in good health. The family history was of some importance in that two sisters had frequently had "chills and fever."

Physical Examination—Temperature 101.4° F, pulse 126, respirations 32. The patient was well developed and well nourished. He looked quite sick and was writhing in pain. The chest was clear. The abdomen was scaphoid, moved almost none with respiration, and palpation revealed board-like rigidity throughout the abdomen, which was most marked, however, in the right upper quadrant. There was moderate tenderness and this was only present in the upper abdomen. The liver and spleen were not palpable and no masses were felt. Rectal examination revealed nothing remarkable and the remainder of the general physical examination was negative.

It was first thought that this patient had a diffuse peritonitis, probably due to a perforated duodenal ulcer. Because of the history, however, and because of the absence of very marked tenderness, malaria was suspected by the Surgical House Officer who saw him in the emergency room, and who had previously seen two of the patients in this group. Smears of the blood were obtained which showed ring forms of *P. vivax* in large numbers.

The patient was admitted to the hospital on the Medical Service. Red blood cell count 2,500,000, hemoglobin 6.5 Gm, white blood cells 5,800. The urine was clear. He was started at once on quinine, receiving 0.6 Gm three times daily. His temperature rose to 104.2° F 18 hours after admission, but he had no chill. His temperature then fell to normal, the symptoms and physical signs disappeared rapidly and the temperature remained normal. He was discharged from the hospital 10 days after admission in good condition.

Case 9—D. S., white, female, age 64, was admitted to the St. Thomas Hospital July 15, 1938. One month before admission she was suddenly seized with severe pain in her right upper abdomen. Shortly after this she had a severe chill. During the following week she was extremely sick with abdominal pain, repeated vomiting and high fever. She was delirious during part of this time but had no more chills. At the end of a week she began to improve and two weeks after the onset she was able to be out of bed. She was then well, except for occasional moderate upper abdominal discomfort, until about 30 hours before admission, when the severe pain again struck her in the right upper abdomen. A few minutes later she had a chill and following this, she had high fever and was delirious. The pain and delirium continued until admission and were accompanied by repeated vomiting. She had no more chills.

The past history revealed that for many years she had been having attacks of milder pain in the right upper abdomen which did not radiate and which often was severe enough to require her to go to bed. Between these attacks she was sometimes troubled with indigestion, characterized by epigastric discomfort and eructation following meals. She had had no chills previous to the present illness.

Physical Examination—Temperature 105.4° F, pulse 110, respirations 30. The patient was a fairly well preserved white woman who looked extremely sick. She was stuporous and answered questions so poorly that most of the history obtained at the time of admission was given by her son. The skin was dry and hot, the face was flushed. There was no jaundice. The chest was clear. The abdomen was symmetrical, slightly distended, and there was marked limitation of respiratory movements on the right side. There was marked tenderness and muscle spasm in the right upper quadrant, and moderate tenderness in the left flank, near the costal margin. The liver and spleen were not palpable at this time but examination was difficult because of the marked tenderness. No masses were felt. The pelvic and rectal examinations were negative and nothing remarkable was found in the remainder of the physical examination.

Red blood count 4,500,000, hemoglobin 13.2 Gm, white count 6,100. The urine was clear.

At this time it was thought that the patient had acute cholecystitis. The presence of malaria was not suspected. Routine blood smear for the differential count, however, showed what was thought to be a few parasites. A thick drop and subsequent smears showed many parasites of tertian malaria.

She was immediately given quinine dihydrochloride 0.6 Gm, intramuscularly, and atebirin 0.1 Gm by mouth. The temperature dropped to normal within six hours and at the end of this time she was more alert, the pain was less marked and the tenderness and muscle spasm were considerably less pronounced. The spleen could then be felt to extend about 4 cm below the costal margin. It was moderately tender. The liver edge could also be palpated but no masses could be felt below it. She received three subsequent doses of quinine dihydrochloride 0.6 Gm intramuscularly at four hour intervals, and on the second day she was started on atebirin 0.1 Gm tid. The temperature remained normal and by the fourth day all abdominal tenderness had disappeared and the spleen was smaller, though still easily palpable. She was discharged from the hospital five days after admission in good condition.

SUMMARY—Six of the patients in this group were admitted as emergencies to the Surgical Service, and the remaining three were admitted to the Medical Service. One of the patients admitted to the Medical was transferred to the Surgical Service soon after admission, and all the patients in the series were carefully observed by the surgical staff until the diagnosis was definitely established, and the abdominal symptoms had subsided.

An analysis of this series of cases reveals the following facts. The diagnosis of malaria was suspected and finally established because of the presence of leukopenia on admission in two patients. A rise in temperature accompanied by a leukopenia, at some time after admission, in three patients. The occurrence of an unexplained chill in two patients. In two patients, the parasites were found in the routine blood smear.

Sudden onset of severe abdominal pain occurred in six patients. In the remaining three the pain was at first relatively mild, and gradually increased in severity. Nausea accompanied the pain in all cases, and vomiting occurred in eight. Only three patients had prodromal symptoms such as headache and general malaise, and in only three patients was there a history of previous attacks of abdominal pain similar to the present illness. The past history was of significance in suggesting malaria as a cause of the symptoms in two patients, and chills occurred during the present illness in only three cases.

Leukopenia was an important finding in most of the cases in this series,

being present on admission in six of the nine patients. In two other cases the white blood count fell below normal after admission, coincident on both occasions with a rise in temperature, and in each case parasites were found at the time of the rise in temperature. The white blood count was elevated in one patient on admission. Only three patients had very high fever at the time of admission. Two others had normal temperatures and in the remaining four cases there was a slight or moderate temperature elevation.

The spleen was felt in only one case, and this patient had such marked abdominal tenderness and muscle spasm that neither the liver nor spleen was palpable until several hours after the parasites had been found and quinine administered. Among the remaining eight patients, the liver could be felt in only one.

In three of the patients in this series, there was definite involuntary rigidity of the abdominal wall at the time of admission to the hospital.

The two patients who gave past histories of malaria had received, as well as could be determined, inadequate treatment. The other eight patients, however, had never had symptoms of malaria and had never received anti-malarial treatment.

The importance of painstaking, unhurried examinations of the blood in cases similar to those reported here cannot be overemphasized. Parasites are often found by the thick-drop method of examination when they are not numerous enough to be seen in smears. In one of this group of patients, parasites were never found in the smears but were easily seen in a thick drop, and in four others thick drops were examined to confirm the findings in the smears. Repeated examinations of the blood were performed in five cases before parasites were seen.

In this group of nine patients, *P. vivax* were found in the blood of seven and *P. falciparum* in the remaining two patients.

CONCLUSIONS

The usual criteria for differentiation of malaria from the common, acute surgical diseases of the abdomen are strikingly inadequate in most of the cases in this series. High fever was not present in most of the patients and abdominal rigidity, which is usually said to be absent in most patients, was present in three of the nine cases reviewed here. The abdominal signs varied greatly, and the usual physical evidences of malaria such as enlargement of the spleen and liver were rarely present.

On the other hand, leukopenia was present in eight of these patients either at the time they were first seen or soon afterward, and this finding, therefore, may be of considerable aid in suggesting the presence of malaria. The examination of a blood smear and thick drop as quickly as possible following a chill or an unexpected sudden elevation of temperature is an important procedure in examination which led to the establishment of the correct diagnosis in five of these patients.

The finding of malaria in the blood of patients who present findings char-

acteristic of intra-peritoneal disease obviously does not exclude the possibility that such a disease may also be present. This is well illustrated in another patient, not included in this series, in whom parasites of tertian malaria were easily found, but who had the classic physical evidences of a spreading peritonitis. Operation was delayed for several hours during which time vigorous antimalarial therapy was administered. Because the symptoms and physical signs were unchanged, celiotomy was then performed, and a perforated duodenal ulcer and localized peritonitis were found.

That abdominal manifestations of malaria may occur fairly frequently is indicated by the fact that eight of the cases reported here occurred among a total of only 266 cases of malaria admitted to the Vanderbilt University Hospital. This total number includes all patients in whom a diagnosis of malaria was made, regardless of the conditions for which the patients were admitted to the hospital.

It is surprising that seven of the patients in this series were found to have tertian malaria, since the predominant organism has been *P. falciparum* in previous reports of cases similar to these. The predominant organism in the temperate regions of North America is *P. vivax*, and these cases serve to call attention to malaria as a problem in differential diagnosis among the acute surgical diseases of the abdomen in the Southern United States.

REFERENCES

- ¹ Castallani, A. Malaria Simulating Various Other Diseases, Including Certain Surgical Conditions. Jour Trop Med and Hyg, 33, 357, 1930.
- ² Gaines, L. M. Unusual Manifestations of Malaria. Jour Med Assn Georgia, 16, 15, January, 1927.
- ³ DePenning, H. C. Malaria and Appendicitis. Brit Med Jour, 2, 53, July, 1928.
- ⁴ Rhodes, R. L. Malaria and Surgical Diseases. Am Jour Surg, 20, 800, 1933.
- ⁵ Taylor, K. P. A. A Valuable Sign in the Differential Diagnosis of Acute Abdominal Malaria. Am Jour Med Sci, 184, 699, 1932.
- ⁶ Ochsner, A., and Murray, S. D. Pitfalls in the Diagnosis of Acute Abdominal Conditions. Am Jour Surg, 41, 343, August, 1938.

CALCIFIED CONSTRICTIVE PERICARDITIS*

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AND

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Case Report—Hosp No 10689 K R, white, male, age 38, was admitted to the Hospital of the University of Pennsylvania, April 18, 1927, with the history of having been confined to bed for several weeks in 1924 with pain in his chest. The details of this illness are not available and a definite diagnosis was not established. His hospitalization was for repair of right inguinal and femoral herniae. At this time he complained of vague, and occasionally cramp-like, abdominal pain. Because of the patient's occupation as a painter, a diagnosis of lead poisoning was considered but subsequent studies failed to establish this. During the operation of herniorrhaphy, it was noted that the peritoneum was inflamed and that an excessive amount of straw-colored fluid escaped from the abdominal cavity. Discharged, May 6, 1927. In June, 1927, a few weeks after operation, the patient was referred to the Gastro-Intestinal Clinic for further studies in regard to his abdominal pain. These studies, including roentgenologic examination of the gastro-intestinal tract, were essentially negative. Shortly thereafter the abdominal pain disappeared.

The patient was next seen in the Gastro-Intestinal Out-Patient Department, November 11, 1935 (Clinic No 30-1122). He came to the hospital because of repeated attacks of quincy, frequent chest colds with cough and expectoration, and weight loss of ten pounds during the preceding year and one-half. Just prior to admission the patient had developed shortness of breath, which, however, was not severe enough to interfere with his daily work.

Physical Examination—The chest was essentially normal, cardiac rate 80, rhythm regular, blood pressure 109/68 in the left arm and 109/70 in the right arm, no cardiac enlargement was demonstrable clinically, there was no systolic retraction of the precordium, no Broadbent's sign. The abdominal examination was negative for liver enlargement and for ascites, there was no peripheral edema, the left external jugular vein was engorged and pulsating.

Roentgenologic examination of the chest was negative for parenchymal disease. It did, however, reveal extensive calcification of the pleura on both sides as well as of the pericardium (Figs 1A and 2A). The heart was slightly enlarged on the orthodiagram, being 21 per cent above the predicted normal.

An electrocardiogram showed a normal rhythm, QRS complex normal, split P waves, P-R interval 0.17 sec, T wave inverted in Leads II and III. These changes were interpreted as indicative of myocardial abnormality.

Blood and urine examinations were essentially negative. Serum calcium 10.5 mg per cent, serum phosphorus 3.3 mg per cent, sedimentation rate 15 Mm in one hour, Kahn and Kolmer negative, intracutaneous tuberculin test (0.01 mg) strongly positive.

Clinical Diagnosis—Polyserositis, involving the pleura, pericardium and peritoneum. This diagnosis was supported by, and gave significance to, the previously undiagnosed episodes of abdominal and chest pain.

Although advised to attend Cardiac Clinic, the patient was not seen for over a year. In August, 1937, he was readmitted to the Medical Service, complaining of shortness of breath, swelling of the feet and ankles and lower sternal pain. He described this pain

* Read before the Philadelphia Academy of Surgery, January 16, 1939. Submitted for publication March 17, 1939.

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as a tight feeling in his lower chest accompanied by a smothering sensation and cough. This occurred only at night, and sitting on the side of the bed for 15 minutes usually afforded relief.



FIG 1—(A) Before operation (B) One year postoperative

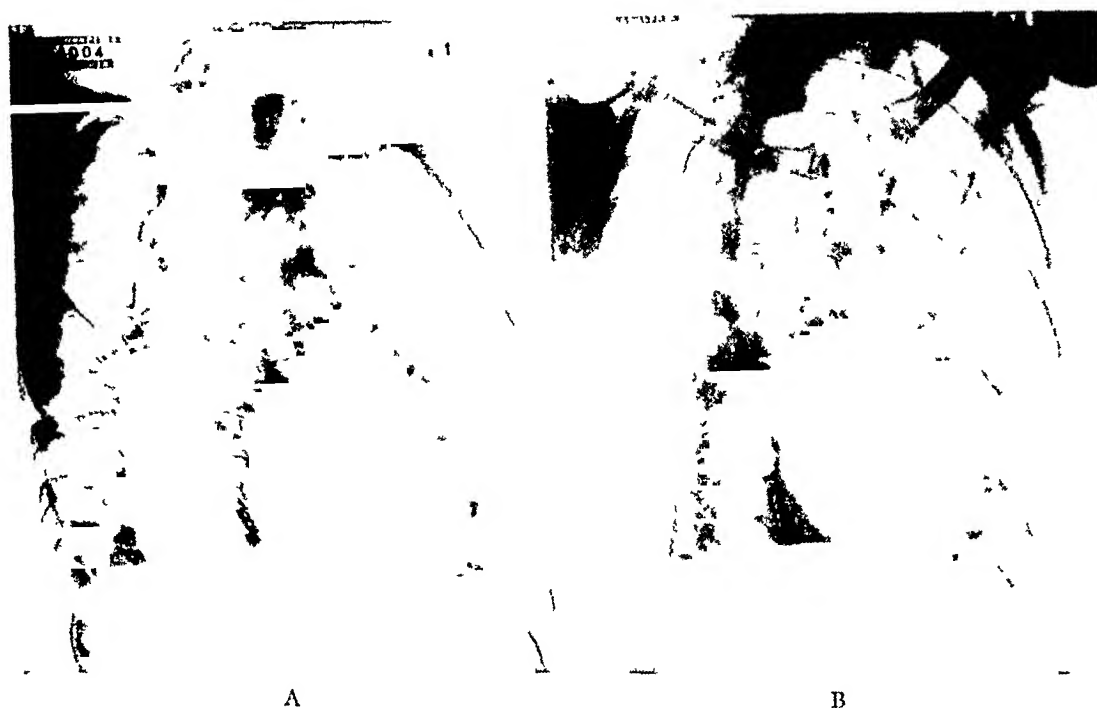


FIG 2—(A) Before operation (B) One year postoperative

Physical Examination revealed slight fever, auricular fibrillation with a pulse rate of 80, heart sounds distant, no precordial pulsation to inspection or palpation, no murmurs, blood pressure 95/70, cyanosis of the lips, marked engorgement of the veins in the neck, basal rales, moderate enlargement of the liver, three fingers below the costal margin, slight ascites and edema of the scrotum and legs.

On a regimen of rest and digitalis the peripheral edema disappeared only to be replaced by a new complaint, a return of abdominal pain. This was generalized and accompanied by diarrhea at the onset. The abdomen was somewhat resistant to palpation and slightly tender throughout. During several weeks of hospitalization, the acute process in the abdomen subsided. However, the amount of fluid had increased steadily. Diuretics including salyrgan failed to check this increase. *Clinical Diagnosis* Chronic constrictive pericarditis. The subsidence of the acute process in the abdomen (serositis) and the presence and persistence of incapacitating circulatory signs and symptoms seemed to show that surgical intervention was indicated.

A preoperative abdominal paracentesis was performed and 4,300 cc of clear, straw-colored fluid were removed. Laboratory studies revealed that the ascitic fluid contained more than the elements of a pure transudate. Specific gravity of 1.020, a protein content of 2.76 Gm per 100 cc of fluid, and counts of 187 red blood cells and 367 white blood cells (78 per cent polymorphonuclears) per cubic centimeter, supported the clinical diagnosis of a superimposed, subsiding exudative phase. Routine culture of the fluid was negative. No acid fast organisms were demonstrable by direct smear. Culture and guinea-pig inoculations for the tubercle bacillus were also negative.

Operation—November 22, 1937. Under intratracheal ether anesthesia, an incision was started at the level of the third rib and continued downward along the left border of the sternum, then outward to the lower border of the sixth rib. The fourth, fifth and sixth costal cartilages were removed in entering the anterior mediastinum. The pericardial constricting lesion was easily demonstrable. A wide, stony, hard band of calcium encircled the heart in its midportion, effectively obliterating all pulsations in this region. It was only above and below this constricting band, at the pulmonary conus and the apex respectively, that the cardiac impulse was visible.

The pericardium was freed from the pleural reflection on the left. The pericardial sac was then entered over the apex of the left ventricle below the calcified band. By carrying this incision upward just inside of and parallel to the left border of the heart, it was possible to free a slightly adherent outer fibrous layer of pericardium from the calcified layer beneath. The edges of this outer layer served very admirably as a tractor to manipulate and steady the heart during subsequent procedures (Fig. 3).

The constricting band was first divided with a rongeur from below upward along the line of the previous incision in the overlying fibrous layer. As soon as this division had been completed, the cut edges were spread apart by the expanding heart, now released from constriction.

The remainder of the operation was devoted to the tedious process of removing the shell of calcium which was fully one-eighth of an inch thick. Fortunately, in most areas it was possible, by very tedious blunt dissection, to separate the calcified covering from the overlying pericardium and the myocardium. Brisk bleeding in one or two spots was adequately controlled by pressure.

After approximately three hours, the anterior, exposed portion of the heart had been divested of its calcified covering. Although the left border of the sternum had been removed with rongeurs to obtain better exposure in this direction, thickened pericardium still remained over the inaccessible portions of the right auricle and in the region of the inferior vena cava.

The possibility of removing the remainder of the pericardial shell through a similar approach to the right of the sternum was considered. It was felt that the patient had had sufficient surgery for the day. The outer fibrous layer of pericardium was now excised. A single Penrose drain was placed in the anterior mediastinum and brought out through the lower angle of the wound which was closed in layers.

Postoperative Course—Convalescence was surprisingly uneventful. The patient was placed in an oxygen tent for the first few days. He alternated between fibrillation and normal rhythm, finally to continue in fibrillation. A nonhemolytic staphylococcal infection developed around the drain but, fortunately, never progressed to the serious stage.

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of a spreading mediastinitis. The patient was discharged approximately seven weeks after operation, greatly improved.

Subsequent Course—The patient has been seen frequently in the Cardiac Clinic since discharge, and the most recent evaluation of the patient's postoperative status, December 15, 1938, approximately one year after operation, is as follows:

The patient is healthy in appearance. He is back at work and exercise tolerance is no longer limited in terms of distance walked or stairs climbed. Blood pressure 130/90.

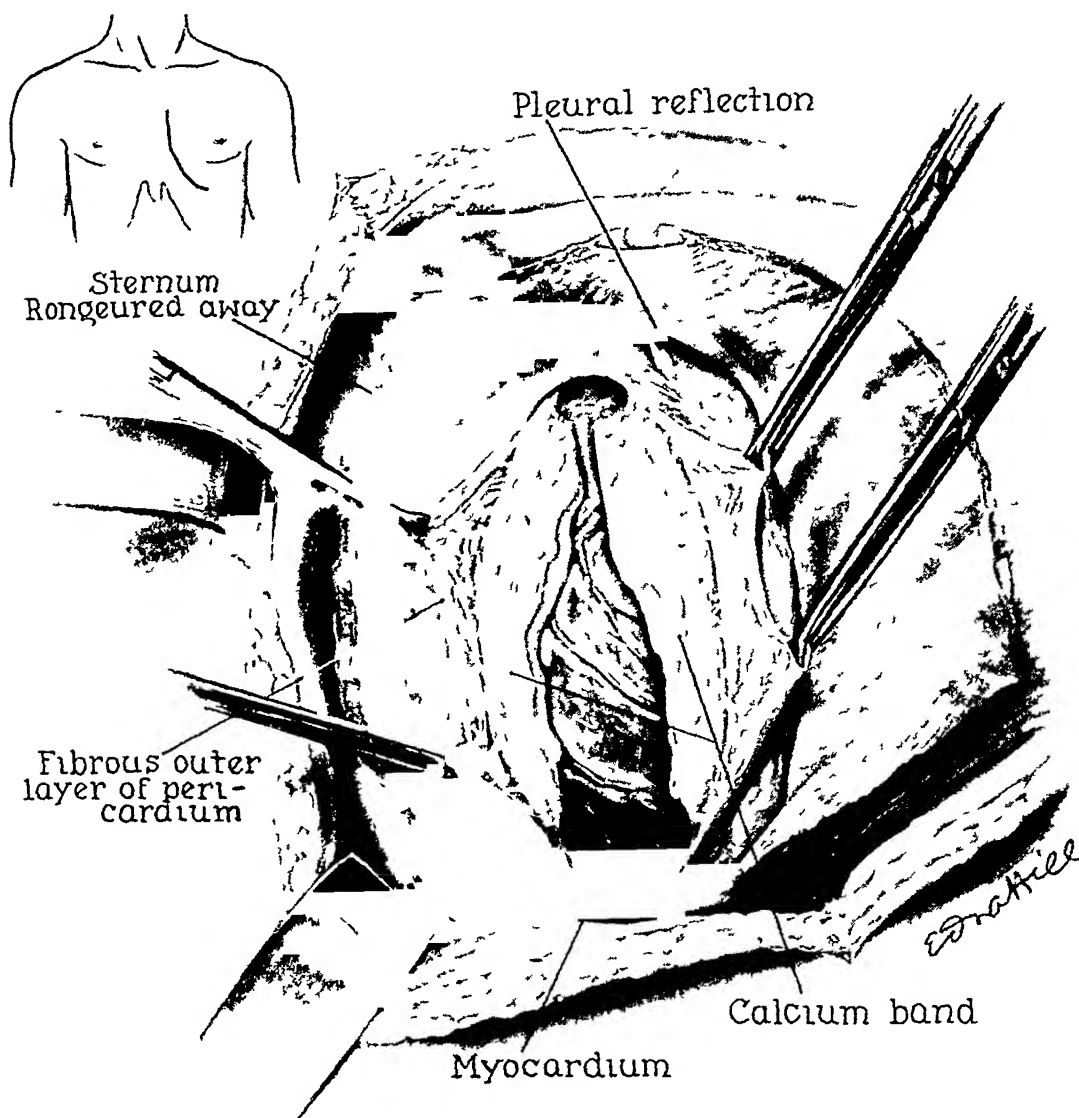


FIG 3—Operative field showing approach and the pericardial layers

—a definite elevation of systolic and pulse pressure. The heart continues to fibrillate—apical rate 84 (digitalis, gr $1\frac{1}{2}$ daily, was stopped at this last visit). No cardiac symptoms, no substernal pain, no cough, no ascitis or edema, no râles.

Venous pressure, as judged by engorgement of cervical veins, has fluctuated since operation. At present it is still somewhat elevated. These veins are empty when the patient is erect but are filled when in a recumbent position, and up to an angle of 30° with the horizontal. The liver edge remains just palpable below the costal margin. Cardiac area, as determined by orthodiagram, is increased 15 per cent over the pre-operative value. Electrocardiogram remains essentially the same.

Balistocardiographic Changes (Fig 4)—These studies were made by Dr Isaac Starr who has published preliminary reports⁴ on the balistocardiograph. Suffice it to say, for our

purpose, that the major waves recorded on a balistocardiographic tracing are primarily due to movement of blood from the heart and around the arch of the aorta with each cardiac systole. The amplitude of these waves is an indirect expression of cardiac output.

Although the abnormal cardiac rhythm in our patient confuses the wave pattern, it, nevertheless, is easy to compare the waves as to amplitude. A definite increase is noted postoperatively, although the amplitude does not reach that of the control. The corresponding increase in pulse pressure and decrease in venous pressure are recorded. An electrocardiogram was taken simultaneously with the patient's postoperative balistocardiogram.

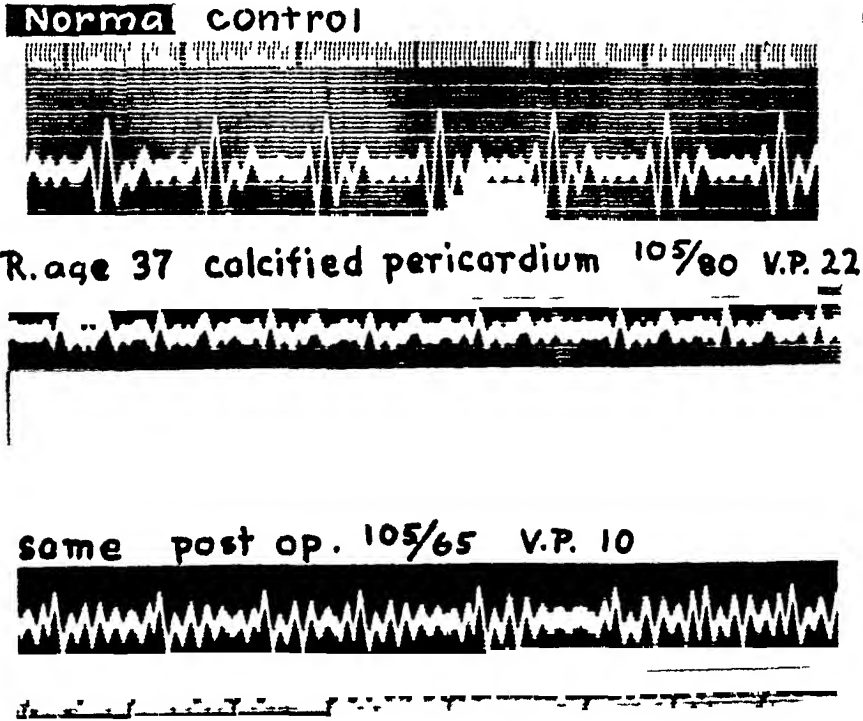


FIG. 4.—Balistocardiogram

Comparison of the preoperative and postoperative roentgenograms shows a marked change in the appearance of the cardiac silhouette with an increase in both the posterior position (Fig 2A and B) and transverse (Fig 1A and B) diameters of the heart following operation. One cannot be entirely sure, however, that part of the shadow on the postoperative film, interpreted as anterior enlargement of the heart, may not be explained on the basis of tissue change following the operation. This comparative study suggests, but does not conclusively demonstrate, the decrease in calcium in the pericardium following its operative removal.

COMMENT—A few points in this case seem worthy of brief comment. The chronology of development of the symptoms is interesting. If we are justified, and it would seem that we are, in assuming that the attack of chest pain in 1924 was the first clinical manifestation of the condition variously called polyserositis, Pick's disease, Concato's disease, concretio pericardii, mediastino pericarditis, etc., fully ten years passed from the date of onset until incapacitating cardiac symptoms developed. That extensive calcification was present in the pericardium for at least two years prior to operation is a certainty.

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Once the cardiac symptoms had become full blown, the patient presented the classic triad of the chronically compressed heart (1) A relatively small, quiet heart (2) High venous pressure (3) Ascites and an enlarged liver

The demonstration of calcium in the pericardium by roentgenologic examination is a definite, but not essential, aid to the recognition of this condition. The diagnosis, as in our case, will, in most instances, be made by the internist. Once diagnosed, the treatment is surgical.

Details of operative technic will not be discussed except for the question of drainage. It is absolutely essential to drain the pericardial space in some manner in order to avoid a postoperative fluid collection with the threat of acute cardiac compression. External drainage is accompanied by the danger of descending infection and the serious complication of a spreading mediastinitis. Although infection developed in this case, it remained relatively superficial. Perhaps in the future it would be better to follow the suggestions of Beck¹ and Griswold⁶ and drain into the pleural cavity.

Prognosis—It is impossible to conceive of a pericardiectomy wound healing without the formation of adhesions tending to fix the heart to the sternum and surrounding structures. However, these extrapericardial adhesions, as opposed to actual pericardial thickening and calcification, are probably of but slight import. Beck¹ states that these adhesions are of no clinical significance unless the heart is actually angulated or twisted. The findings of Hosler and Williams² support this statement. They studied, at autopsy, 76 cases with extensive pericardial adhesions. Cardiac hypertrophy had occurred only in those individuals in whom concomitant heart or valvular disease was demonstrable.

Churchill³ collected 37 cases, which had had a decortication of the heart for adhesive pericarditis. In five instances, the operation was interrupted for one reason or another. Of the remaining 32, 19, or 59 per cent, obtained excellent results. The operative mortality was 22 per cent.

More recently, Schmieden and Westermann,⁵ some of whose cases were included in Churchill's statistics, have reported the end-results of 22 operations for constrictive pericarditis. Six patients enjoyed a restoration to full health, six were markedly improved, one died at operation, seven died post-operatively, and two died after transitory improvement.

In our case, the patient may be classified as an excellent result to date, approximately one year after operation. However, it must be acknowledged that evidence of slight cardiac compression persists, and it is possible that, sometime in the future, further surgery may be indicated.

Dr Francis C Wood, of the Cardiac Clinic of the Hospital of the University of Pennsylvania is responsible for the extensive and careful medical study which was carried out on this patient, and we wish to thank him for the privilege of reporting the results of his efforts.

REFERENCES

- ¹ Beck, C S. Acute and Chronic Compression of the Heart. *Am Heart Jour*, 14, 515, 1937.

- ² Hosler, R M, and Williams, J E A Study of Cardiopericardial Adhesions Jour Thoracic Surg, 5, 629, 1936
- ³ Churchill, E D Decortication of the Heart for Adhesive Pericarditis Arch Surg, 19, 1457, 1929
- ⁴ Starr, Isaac Personal communication, also Starr, Isaac, Rawson, H J, and Schroeder, H A Apparatus for Recording the Heart's Recoil, *etc* Am Jour Physiol, 123, 195, 1938
- ⁵ Schmieden, V, and Westermann, H H The Operative Management of Fibrous Constricting Pericarditis Surgery, 2, 350, September, 1937
- ⁶ Griswold, R A Chronic Cardiac Compression Due to Constricting Pericarditis J A M A, 106, 1054, 1936

DISCUSSION—DR FRANCIS C WOOD (Philadelphia, Pa.) Some reports of the postoperative course of Pick's disease suggest that a rather dramatic, immediate improvement in the circulation occurs as soon as the heart is released from compression. Such was not the case in our patient. For several days there was no definite change in his condition. Then, very slowly, improvement began and continued over a period of several weeks. Dr Paul White's report (Lancet, 2, 539, September 7, 1935) of the cases studied by him and Doctor Churchill, in Boston, indicates that there is, as a rule, a period of from three to seven days after operation, before diuresis begins. Doctor Atkins tells me the same delay in the onset of improvement has been noted in Doctor Beck's cases in Cleveland. The reason why that latent period occurs is not understood.

Although tuberculous pericarditis can produce chronic cardiac compression, Burwell and Blalock's paper (J A M A, 110, 265, January 22, 1938) is the only one I know of, which reports an appreciable incidence of cases with tuberculous etiology. White states that the etiology of the pericardial lesion in Pick's disease in ten of his 15 cases was "uncertain or unknown", only two had tuberculous pericarditis. No tuberculous lesions were demonstrated in our patient. The high incidence of tuberculosis in Burwell's series may be due to the fact that 19 of his 21 cases were reported from Nashville, Tennessee. Consequently, his group may have contained a higher proportion of Negroes than the groups reported from Boston and Cleveland.

DR ELDRIDGE L ELIASON (closing) The opening was made in the pericardium just below the constricting band. The calcified area was then separated millimeter by millimeter, and then removed with a rongeur forceps. Twice, a slight wound was made in one of the cardiac veins resulting in a rather active hemorrhage. The pericardium was not completely removed. The anterior mediastinum was drained.

N B—Patient's last follow-up examination was made on February 6, 1940, two years after operation. Condition was essentially that of December, 1939. There was no evidence of increasing cardiac compression.

DANGER IN THE USE OF LOCAL INFILTRATION ANESTHESIA IN OPERATIONS UPON MALIGNANT TUMORS*

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THE MOST DIFFERENTIATING FEATURE between benign and malignant tumors is the ability of malignant tumors to produce metastases. Any factor, therefore, which tends to accelerate or diminish the formation of metastases is of the greatest importance in the care of tumors. Unfortunately, the most potent factors in the production of metastases, that is, the type of tumor and degree of malignancy, are entirely beyond one's control.

There are, however, certain clinical procedures which, when improperly performed, may tend to produce metastases, *i.e.*, biopsy, palpation of tumor, and operation for removal of tumor.

Biopsy, utilized by Schich¹ in 1851, and by Thiersch¹ in 1865, and introduced as an indispensable routine method into the clinical laboratory by Ruge,¹ in 1879, has been questioned as a possible cause of spread of metastases. Animal experimentation, however, does not support this view. Wood² inoculated 400 animals with Flexner rat carcinoma, a growth that normally produces metastases to the lungs in 20 per cent of the animals. Two hundred of these animals had a biopsy performed, 200 were kept as controls. Ten days after the biopsy all tumors in both groups were removed. Several months later the animals were killed and autopsies performed. There was no difference in the incidence of metastases in the lungs in the experimental and control animals.

It has long been the opinion of many clinicians that cancer may be disseminated by trauma. Gerster,³ as early as 1885, in a paper on the "Surgical Dissemination of Cancer," says that one of the advantages of extremity amputation for cancer is that operation at a distant point from the tumor obviates handling of the lesion with consequent dissemination. This was, however, entirely a matter of opinion until Tyzzer,⁴ in 1913, performed experiments to determine the effect of massage on the spread of cancer metastases from tumor transplants in mice.

Taking 22 Japanese waltzing mice, Tyzzer inoculated them with tumor, and 27 days later separated them into two comparative series on the basis of size of the implanted tumor. One group was manipulated and massaged repeatedly and all the mice were killed 46 days after inoculation. Of the 11 massaged tumor mice, seven (66 per cent) were found to have metastases in

* This research was made possible by a grant from the Cancer Institute Research Fund supported through the Citizens Aid Society.

Submitted for publication March 3, 1939.

the organs, especially the lungs, while only three (27 per cent) of the control mice had such metastases, ($P = 0.294$)* In another series of 20 Japanese waltzing mice, divided and treated in practically the same manner, the results were that in ten massaged mice, eight (80 per cent) developed metastases, ten controls developed no metastases, ($P = 0.013$)

In still another group of 12 controls and 12 experimental Japanese waltzing mice, Tyzzer found metastases in four (33 per cent) massaged tumor mice and zero of the control mice ($P = 0.061$)

In all of these experiments conditions were sufficiently similar to combine the data, and in addition two others of his mice, one with massaged tumor and one control, can be added, to give 34 mice with massaged tumors, in which 20 (66 per cent) were found to have metastases, and 34 control mice, in which three (9 per cent) developed metastases, ($P = 0.002$) In two tumors which do not produce spontaneous metastases, *i e*, Ehrlich mouse tumor 11 and Jensen rat sarcoma, Tyzzer was unable to produce them with massage

Knowl^{5, 6} performed experiments similar to those of Tyzzer with transplanted animal tumors but used a number of different tumors, both carcinoma and sarcoma She concluded that those tumors which metastasize spontaneously in a high percentage do not show as great an increase after massage as do those in which spontaneous metastases are low

The plan adopted in this report is to group all her material into two groups—carcinoma and sarcoma—and analyze each of these as a whole, for significant difference in those with massaged tumors and those without massage, or the controls

In the carcinoma group there were 29 Flexner rat carcinomata, 20 Bond mouse carcinomata, 23 Ehrlich mouse carcinomata, 41 Crocker Fund mouse carcinomata No 5, 80 No 11 and 24 No 48 There were in this material 111 animals with massaged carcinomata in which 35 (31 per cent) were found to have metastases at autopsy and 106 control animals in which 25 (24 per cent) developed metastases, ($P = 0.325$)

In the sarcoma group there were 28 Crocker Fund mouse sarcomata No 7, 180 Crocker Fund mouse sarcomata No 181, and 57 Ehrlich mouse sarcomata There were in this material 133 massaged tumors in which 37 (28 per cent) were found to have metastases, and 132 controls in which 29 (22 per cent) were found to have metastases, ($P = 0.393$)

Marsh⁷ made similar experiments with spontaneous mouse tumors These spontaneous tumors are presumably more like the clinical tumors with which the surgeon has to deal, but infiltration even in these tumors is rare, they are well circumscribed tumors with a tendency to encapsulation and, hence, probably much less prone to produce metastases than are the infiltrating diffuse human breast cancers Marsh had 50 albino mice bearing epithelial tumor of the breast as experimental animals which were massaged, and at death 31 (62 per cent) had macroscopic pulmonary metastases He had 459 controls in

* Signifies that there are 29 chances in 100 for such a difference as exists between these two groups to arise by sampling

which 184 (40 per cent) were found to have pulmonary metastases at death, ($P = 0.074$)

It would seem proper to draw the conclusion from these experiments of Tyzzer, Knox and Marsh that there is a slight tendency for rough handling or massage of malignant tumors to disseminate the lesion, and that it is variable according to the type of lesion manipulated. Rous, on the other hand, makes the statement that he massaged some adenocarcinomata in rats with the result that the animals all died, but it did not cause the tumor to go into the blood stream any more than ordinarily.

If massage will disseminate malignancy, it might be expected that the trauma incident to operative removal would have the same effect though perhaps to a lesser degree.

Clunet⁸ found in 145 nonoperated mice bearing tumor M, there were no visible metastases at autopsy following natural death, but in 111 operated mice bearing the same tumor, five were found at autopsy to have developed metastases ($P = 0.000$). In mice with another tumor F the same type of experiment was performed. In 230 control animals there were two with visceral metastases, and in 24 which had been operated upon there were nine with visceral metastases, ($P = 0.000$).

Tyzzer⁴ operated upon five Japanese waltzing mice bearing tumor and had two others for control. Three of those operated upon and both of the non-operated mice had metastases at autopsy. In another series of Japanese waltzing mice with tumors, he had 21 controls and 19 experimental animals. In these animals he recorded not only the individual incidence of metastases, which were present in all except one control and one experimental animal, but he also recorded the number of metastases found in each animal and the days the animal lived after inoculation. A comparison of the mean of number of metastases for these data gives ($P = 61.7$). A similar comparison of the mean number of days the animal survived after inoculation quite definitely that the animals with operation had a longer survival as a result of the operation ($P = 0.019$).

It would, therefore, seem to be not definitely settled that operation does tend to produce metastases since the experiments of Clunet indicate that it does and similar experiments of Tyzzer indicate that it probably does not produce metastases.

The clinical impression has been gained that local infiltration anesthesia may occasionally cause dissemination of malignancy. This impression came from the occasional case of carcinoma which developed an extensive local dissemination or metastases to regional nodes after operation under local infiltration anesthesia.

To check this impression animal experiments were carried out by inoculating various tumors into mice and when the tumors had reached a proper size they were divided into control and experimental groups. The tumors in the control group were removed under anesthesia and at approximately the same interval after inoculation the tumors in the experimental group



FIG 1—Tumor 224—Lung metastases (X65)

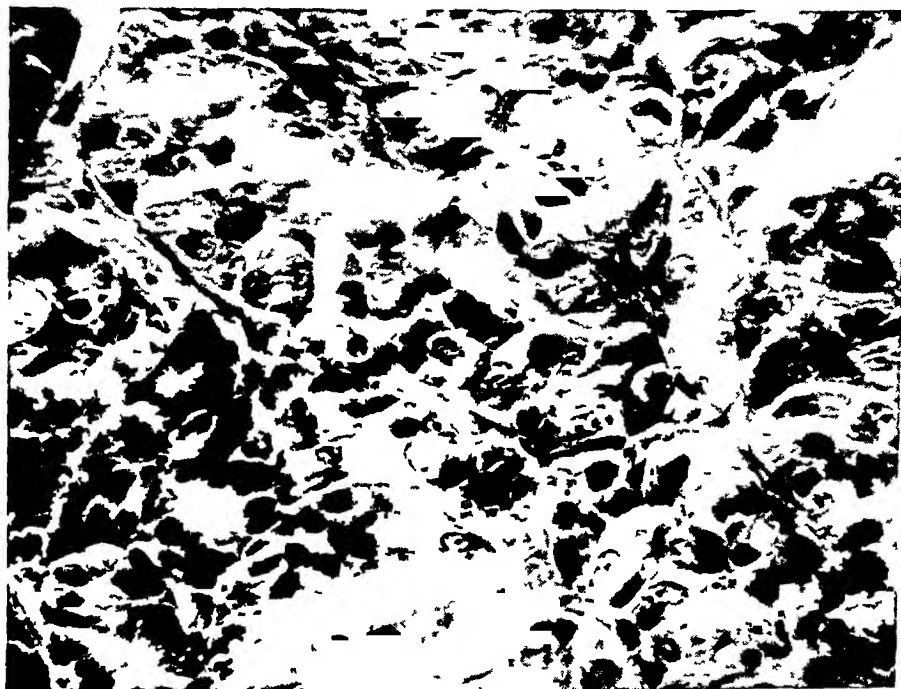


FIG 2—Same as Figure 1 (X360)

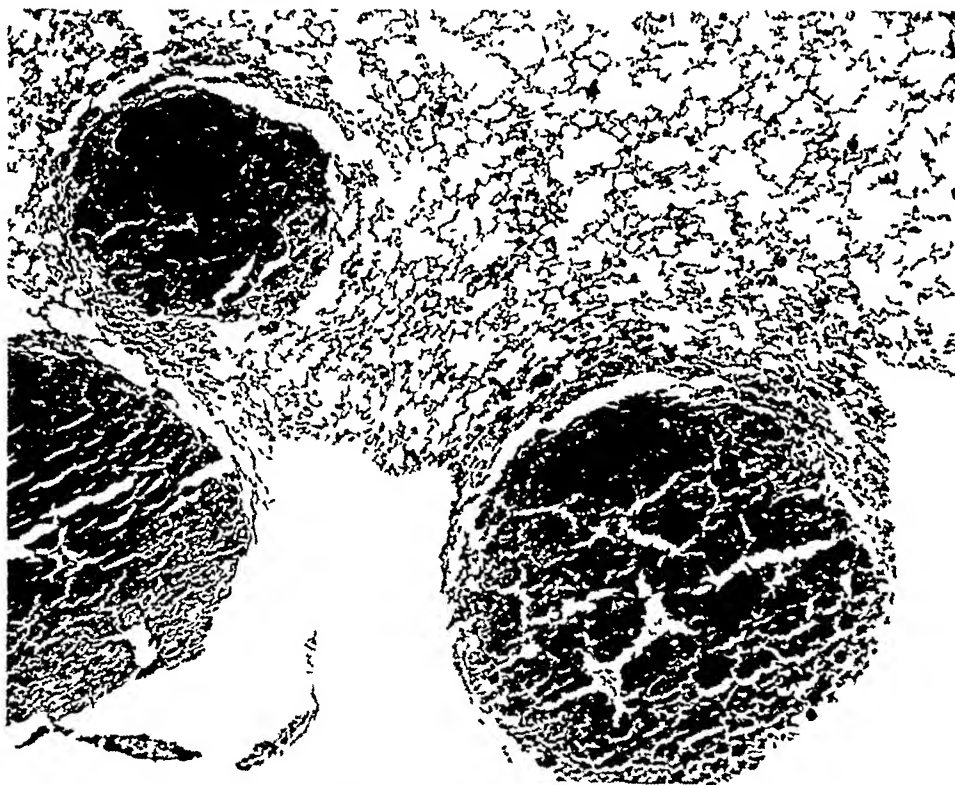


FIG 3—Tumor G—Lung metastases (×65)

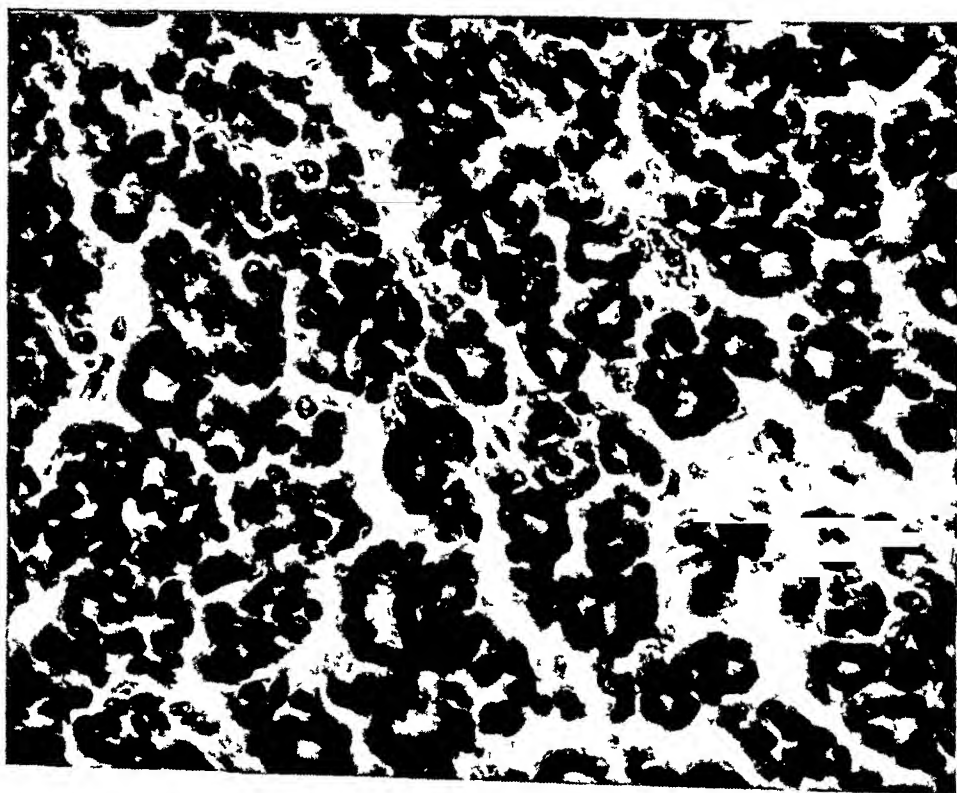


FIG 4—Same as Figure 3 (×360)

were removed under anesthesia, but in addition 1 cc of a 0.5 per cent solution of novocain was injected about the tumor in the experimental animals

The results of these experiments were

Sarcoma 180	
Control, 50 mice	Pulmonary metastases 0
Experimental, 50 mice	Pulmonary metastases 2
$P = 0.162$	

It was concluded that this tumor was not satisfactory because as a rule local recurrence would kill the mouse before metastases were produced

Adenocarcinoma 224 (Figs 1 and 2)	
Control, 46 mice	Pulmonary metastases 9
Experimental, 46 mice	Pulmonary metastases 15
$P = 0.273$	

This tumor was tested for its ability to produce spontaneous metastases when allowed to carry the tumor 40 to 50 days without any manipulation or operation. In 18 mice metastases developed in six, or 33 per cent. It was concluded that this tumor has too great a tendency to produce spontaneous pulmonary metastases to give the most conclusive results. Knox⁵ had previously noted this difficulty in working with tumors which readily produce metastases.

Tumor G (Figs 3 and 4)	
Control, 48 mice	Pulmonary metastases 5
Experimental, 58 mice	Pulmonary metastases 20
$P = 0.020$	

Tumor D in dba mice	
Control, 40 mice	Pulmonary metastases 4
Experimental, 42 mice	Pulmonary metastases 13
$P = 0.058$	

These experiments would seem to indicate that the common surgical practice of injecting local infiltration anesthesia for biopsy or removal of malignant tumors is a dangerous procedure and should be discontinued.

REFERENCES

- ¹ Hellwig, C. A. Biopsy in Tumors. *Arch Path*, 13, 606, 1932.
- ² Wood, F. C. The Experimental Pathology of Cancer. *J A M A*, 84, 4, 1925.
- ³ Gerster, H. G. On the Surgical Dissemination of Cancer. *New York Med Jour*, 41, 233, 1885.
- ⁴ Tyzzer, E. E. Factors in the Production and Growth of Tumor Metastases. *Jour Med Research*, 28 (or new series 23), 309, 1913.
- ⁵ Knox, L. C. The Relation of Massage to Metastasis in Malignant Tumors. *ANNALS OF SURGERY*, 75, 129, 1922.
- ⁶ Knox, L. C. Trauma and Tumors. *Arch Path*, 7, 274, 1929.
- ⁷ Marsh, M. C. Tumor Massage and Metastases in Mice. *Jour Ca Research*, 11, 101, 1927.
- ⁸ Marie, P., and Clunet, J. Frequence des metastases viscerales chez les souris cancéreuses apres ablation chirurgicale de leur tumeur. *Bull de l'ass Française pour l'etude du cancer*, 3, 9, 1910.

FOLLICULAR LYMPHOBLASTOMA

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IN 1925, a disease entity called at first "giant hyperplasia of the lymph nodes and spleen" and later "follicular lymphoblastoma" was crystallized out of a group of generalized lymphadenopathies with splenomegaly by Brill, Baehr and Mandelbaum⁴. The disease was first thought to be benign, but the course in many instances proved otherwise. Hence the change of the name from "hyperplasia" to "lymphoblastoma". Clinically, the separation of this entity from the group of lymphoblastomata seems justified because, until now, the diseased tissues have been found to be extremely radiosensitive and a few of the patients involved have been able to be kept alive for as long as 13 years after the onset of the disease.

Case Report—Hosp No 73782 A P, white, female, age 37, was admitted to the Lincoln Hospital, August 3, 1937, complaining of pain in the lower left chest and loss of 32 pounds during the four preceding months. She had had whooping cough in childhood. In 1925, an abortion, and during the same year developed a pleurisy on the left side, which lasted three to four days and disappeared after strapping and sedation. In 1927, a hysterectomy. In June, 1937, coryza, followed two days later by "pleurisy" with pains in the left lower chest, lasting four to five days.

Present History—Eleven days before admission to Lincoln Hospital, she had another episode of similar chest pain in the same region. The pain was stabbing in character and was aggravated by breathing. It was refractory to therapy and continued unabated until admission. Night sweats were noted as well as weakness. No history of tuberculosis, nor had she had any contact with tuberculous cases. No prolonged cough, no hemoptysis. Lues denied. No familial history of splenomegaly or any other disease.

Physical Examination—A mass was palpated in the left upper quadrant of the abdomen which extended from beneath the left rib margin to the umbilicus. It was hard, non-tender and had a definite sharp edge. The liver extended two to three fingers' breadth below the right costal margin, it was not tender and had a sharp edge. On inspiration, a rub was heard over the mass in the left upper quadrant. No other pathologic findings. Blood pressure 120/80.

Laboratory Data—Urine: Albumen 0 to trace, glucose and acetone negative, specific gravity 1.004. Microscopic examination showed W B C in clumps, occasional R B C, no casts. **Hematologic Findings**: Fragility test for R B C normal. The bone marrow, obtained by sternal puncture, showed a great increase in the number of lymphocytes (Doctor Vogel).

August 6, 1937

Hb 79% (Sahli, 17 Gm equal 100%)	Nonsegmented polys	4
R B C 4.6 million	Segmented polys	56
W B C 4,800	Lymphocytes	31
Platelets 210,000	Monocytes	4
Reticulocytes—less than 0.5%	Eosinophils	2
	One lymphocyte was seen in division	

Submitted for publication February 23, 1939

August 19, 1937

Hb 69% (Sahl, 17 Gm equal 100%)	Nonsegmented polys	4
R B C 4 1 million	Segmented polys	46
W B C 6,200	Lymphocytes	42
Platelets 190,000	Monocytes	4
	Eosinophils	3
	Basophils	1

Two lymphocytes were seen in amitotic division. A definite diagnosis of leukemia could not be made from the smear and the bone marrow at this time.

Intravenous and retrograde pyelograms revealed a double ureter on the left side and a somewhat enlarged kidney shadow. There was also a slow, unsatisfactory excretion of indigo carmine from the left kidney. Roentgenograms of the lumbosacral spine and lungs were negative. A barium enema was negative.

The differential diagnosis, apparently, lay between (1) Aleukemic leukemia (2) Banti's syndrome (3) Neoplasm of the kidney.

One of the first diagnoses entertained was that of Banti's syndrome because of the enlarged liver, spleen and the leukopenia. This was discarded after the bone marrow study was made. The two factors which led to the consideration of the diagnosis of aleukemic leukemia were: First, the tumor in the left upper and left middle quadrant of the abdomen, which was assumed to be spleen by some because of its sharp and notched edge, and second, the increased number of lymphocytes in the sternal bone marrow smear. The genito-urinary consultants believed, however, that there was a possibility that the abdominal tumor was a kidney, being influenced by the impaired kidney function and the urinary findings to consider them evidence of a possible renal neoplasm or nephritis.

In order to settle the question as to what organ in the abdomen comprised the tumor, the mass was punctured and a biopsy obtained. This proved to be composed, almost entirely, of small round cells. It was, therefore, decided that the tumor was the spleen. The question as to the kidney findings, however, still remained unsolved, as there was no history of nephritis, and since the results of the bone marrow puncture were not deemed conclusive enough to definitely establish the diagnosis of an aleukemic leukemia, an exploratory celiotomy was performed to find exactly what was present in the abdomen.

Operation—August 28, 1937. *Operative Pathology* Large, smooth spleen, weighing 2,000 Gm, blue with a dusky redness throughout, very soft and rather friable, with a moderate perisplenitis (very thin adhesions connecting spleen to diaphragm and parietal peritoneum). Marked retroperitoneal and mesenteric adenopathy, with superficial edema.

Operative Procedure—Abdomen opened through an eight-inch midrectus incision. Abdominal cavity well walled-off after identifying the pathology present. Careful separation of spleen from abdominal parietes and diaphragm. The spleen was delivered into the wound, and its pedicle ligated *en masse* with chromic No. 2. The artery and vein were then separately ligated with chromic No. 2. A small node in the mesentery was removed for pathologic examination. Wound closed.

The patient was discharged, September 19, 1937, and sent to the Mt. Sinai Hospital, New York City, for roentgenotherapy.

Pathologic Examination of the Spleen—Path No. 5023. Drs. Spirtes and C. R. Brown. *Macroscopic* The spleen was soft and friable, weighing 1,800 Gm, and measuring 30 × 22 × 15 cm. Transection through the organ revealed an unusual appearance. The pulp was composed of innumerable larger and smaller nodules which were firm and white and measured between 2 to 5 Mm in diameter. These nodules composed the greater part of the splenic parenchyma. The red pulp was reduced to a mere supporting stroma between the nodules. Several large venous channels were visible (Fig. 1). There was an enlarged lymph node at the hilus.

Microscopically, the capsule is moderately thickened. Very few connective tissue strands arise from the capsule and penetrate the splenic pulp. A large number of

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malpighian bodies of varying size can be seen in the pulp, which is so compressed as to be reduced to mere streaks between the numerous lymph follicles. The smaller follicles are mostly subcapsular, the larger ones more central. The sinuses in many of these follicles frequently contain pink, acellular, homogeneous masses of tissue in hematoxylin and eosin sections. With phosphotungstic acid-hematoxylin stain, these masses stain like fibrin although they do not have its fibrillar structure. The center of each follicle appears

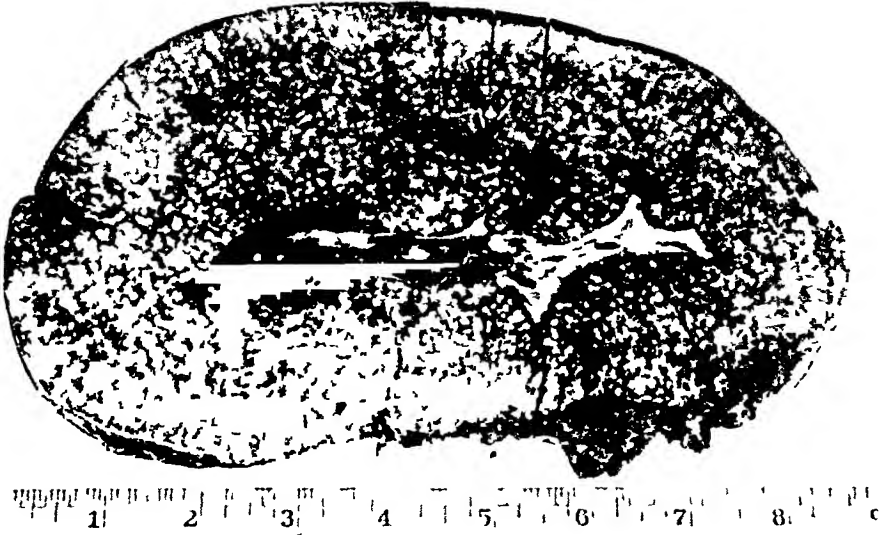


FIG 1—Transection through spleen removed at operation

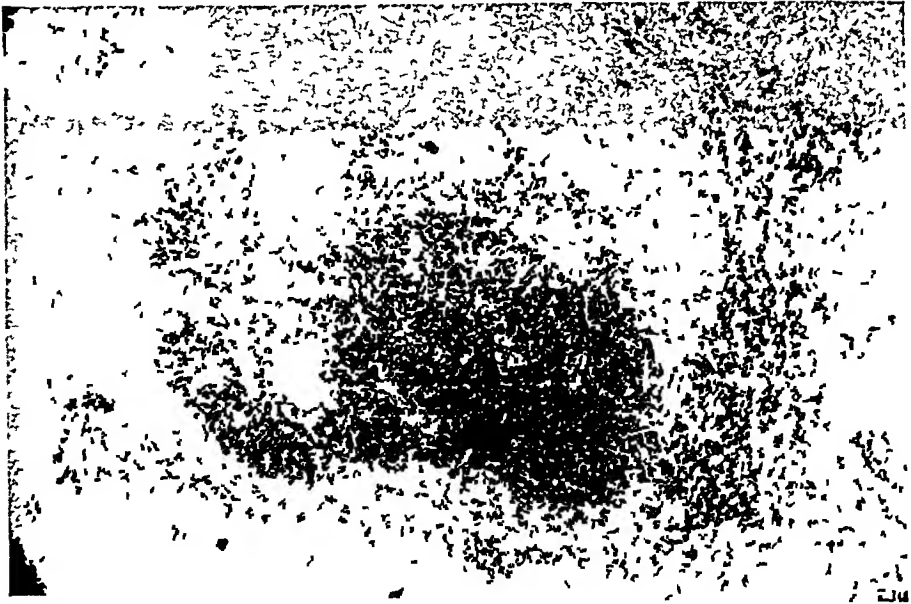


FIG 2—Photomicrograph of a giant follicle (Low power)

somewhat lighter than the periphery, which is more cellular, the darker periphery, in turn, is surrounded by a lighter-staining zone of compressed pulp. The cells of the central and peripheral parts of the follicle do not differ. The predominant cell is a lymphocyte with a rounded or slightly oval-shaped nucleus somewhat larger than the nucleus of a normal lymphocyte. The nuclear chromatin is not clumped as in a normal lymphocyte and the nucleus, therefore, appears lighter. Definite protoplasmic borders cannot be made out. Interspersed amid the lymphocytes are larger reticulum cells with large, light-staining nuclei surrounded by a definite nongranular cytoplasm. Few mitoses are seen. The compressed pulp is not very cellular and contains many reticulo-endothelial cells in

narrow sinuses whose long diameters encircle the follicles. There is a moderate infiltration of the pulp with lymphocytes similar to those of the follicles. A few polymorphonuclear cells and some erythrocytes are also seen in the stroma. The absence of hyaline thickening of the arteries of the pulp is unusual (Fig 2).

Pathologic Examination of Lymph Node at the Hilus of the Spleen—Macroscopic Size 2 x 2 x 1 cm. The capsule is thin and adherent to the surrounding tissues. Cut section shows a grayish, homogeneous appearance without definite follicles.

Microscopically, the capsule is not thickened but is infiltrated with pathologic and normal lymphocytes. The infiltrated cells are pressed between the connective tissue strands of the capsule into long rows and have somewhat elongated nuclei. The peripheral sinus is likewise filled with these cells. No definite, sharply defined follicles are present. The abnormal lymphocytes are from focal collections in various points over the whole node. In the center of the lymph node there can be seen some normal-appearing supportive connective tissue containing few cells, many of which are of the large reticulum cell type. There is a large cluster of pathologic lymphocytes in the adventitia of an arteriole just outside the capsule.

Subsequent Course—October 21, 1937. The patient was readmitted to the hospital essentially for the performance of a bone marrow biopsy. The abdominal wound was found to be firmly healed. The only additional finding on physical examination was a mass on the right side of the abdomen extending from the costal margin to the right lower quadrant and also over the midline to the left upper quadrant of the abdomen. This mass was irregular, nontender and freely movable. It lay partly over the liver in the right upper quadrant and was thought to be enlarged mesenteric lymph nodes.

The Peripheral Blood showed the following

Hb 85% (Sahl, 17 Gm equal 100%)	Nonsegmented polys	4
R B C 5.2 million	Segmented polys	37
W B C 16,800	Lymphocytes	51
Platelets 240,000	Lymphoblasts	1
Reticulocytes—less than 0.5%	Monocytes	5
	Eosinophils	1
	Basophils	1

There is, therefore, a leukocytosis with a slight lymphocytosis present. Many lymphocytes showed amitotic division and there was an occasional lymphoblast (1 per cent) to be seen. *This was the first indication, in the peripheral blood, of leukemia.*

Bone Marrow—The specimen obtained at biopsy was found to be entirely infiltrated with lymphocytes (Fig 3).

The patient was discharged again, October 27, 1937, to Mt Sinai Hospital for further roentgenotherapy.

Second Readmission, July 8, 1938. For soreness of the mouth and gums. The patient had been receiving roentgenotherapy to various nodes at Mt Sinai Hospital since her first readmission. The roentgenologic report from the Mt Sinai Hospital stated that enlarged nodes were present at first in the left postcervical region. The liver was enlarged two fingers' breadth below the costal margin and a mass was felt in the upper abdominal region. Under roentgenotherapy the patient improved and the nodes became smaller, however, other nodes enlarged from time to time. All in all, she received roentgenotherapy from November 4, 1937, to June 27, 1938, at irregular intervals depending upon the clinical status.

Physical Examination—Temperature 103.6° F, pulse 100, respirations 24. Blood pressure 134/80. Examination revealed a swelling of the gums over the incisor teeth with a few small bleeding points. Numerous pinhead-sized patches with a whitish-gray deposit on the surface of gingival mucosa about the mouth. The tongue and pharynx negative. The neck showed many enlarged lymph nodes both anterior and posterior to the sternocleidomastoid muscle. There were definitely diminished breath sounds and dulness over

the chest over the lower third of the left lung field. The heart was essentially negative. *Abdomen* The scars in the left upper and right lower rectus region were both well healed. The liver was palpable at the umbilicus. The extremities were normal. *Lymph Nodes* There were numerous supraclavicular and axillary nodes bilaterally, and an enlarged node was felt in the left inguinal region. The epitrochlear nodes were not palpable.

Laboratory Data—Blood count on the day of admission at Mt. Sinai Hospital showed WBC 2,300, Hb 72 per cent (Sahli). At the Lincoln Hospital the WBC were 3,600, RBC 3,350,000, Hb 72 per cent (Sahli, 17 Gm equal 100 per cent). *Differential* Polys 10 per cent, monocytes 2 per cent, basophils 4 per cent, and lymphocytes 50 per cent. Undifferentiated cells (appearing like large lymphocytes) 34 per cent. The blood work-up in this case was performed by an intern and may not, therefore, be entirely reliable. However, it indicates an abnormally large number of lymphocytes with many



FIG 3—Photomicrograph of the bone marrow biopsy showing infiltration with lymphocytes (Low power)

immature forms. At the same time, a certain degree of agranulocytosis was noted, evidently due to the prolonged roentgenotherapy, which was administered for seven months. Roentgenograms of the chest revealed pleural effusion in the lower part of the left lung. The mouth lesions, the soreness and swelling subsided with rest and the discontinuance of the roentgenotherapy. The temperature slowly dropped from 104° F, on admission, to normal by July 12, 1938. Subsequently it occasionally rose to 100° F, but returned to normal within a few days. Urine negative. Patient was discharged, July 31, 1938.

October 6, 1938. The patient was seen in the Out-Patient Department and states that she had gained a great deal of weight and felt fine. A large, palpable mass was felt three and one-half fingers' breadth below the costal margin on the right side—apparently liver. In the umbilical area, there was a suggestion of a mass which might very well have been intra-abdominal lymph nodes. No edema of the extremities, a few palpable nodes could be found in the posterior triangle of the neck on the right side behind the sternocleidomastoid. The patient weighed 138 pounds. Roentgenotherapy had not been resumed.

Since October, 1938, the patient began to complain of cough and developed ascites and peripheral edema. She entered Mt. Sinai Hospital for a chest tap, and then Lincoln Hospital, where a pleural effusion was tapped several times and she was treated with diuretics. She entered Montefiore Hospital in October, 1939. At that time she had

generalized lymphadenopathy, the liver was palpable two fingers' breadth below the umbilicus, and there were emaciation and ankle edema. She did not respond to chest taps and diuretics. She developed ulcerative stomatitis, became very toxic and weak and died during November, 1939.

During her stay at the Montefiore Hospital her white blood count was 13,600, 60 per cent polys, 39 per cent mature-appearing lymphocytes, and 1 per cent lymphoblasts Hb 88 per cent.

Autopsy—Generalized lymphadenopathy was present. Ascites was evident. There was a long left rectus scar on the abdomen, and edema of the lower extremities and sacrum. An abdominal flap incision was performed and 3,500 cc of slightly sanguineous ascitic fluid was removed from the peritoneal cavity. The omentum was bunched together in the left upper quadrant and seeded with small tumor nodules. The liver extended down to the level of the umbilicus, was very pale and full of round, white, firm tumor nodules. There were 2,500 cc of yellowish, cloudy fluid in the left pleural cavity. The hemiazygos and azygos veins were distended and prominent. Tumor nodules could be seen in the parietal and visceral pleura near the diaphragm. Bronchopneumonia was seen in the left lower lung. The pulmonary hilar nodes were enlarged bilaterally and were soft, pinkish in color, and showed some anthracosis. The nodes extended along the thoracic aorta and invaded the upper portion of the parietal pericardium. The heart was essentially negative. The para-aortic nodes were enlarged throughout the length of the aorta, and invaded the surrounding structures. They appeared to press on the vena cava inferior. There was a tumor nodule 2 cm in diameter seen in the wall of the gallbladder. A few small, ulcerated tumor masses could be seen in the lumen of the jejunum and ileum. The wall of the sigmoid was also invaded by tumor tissue. The left kidney capsule was thickened and invaded by tumor. Two pelves and two ureters could be seen on this side. All of them were surrounded by a solid mass of tumor invading the outer walls. The tumor also extended upward and invaded the substance of the kidney. Both pelves and ureters of the right kidney were slightly dilated. The other kidney was essentially negative. No uterus, tubes or ovaries were found. The peritoneum of the pouch of Douglas was extensively invaded by tumor.

Microscopic Examination—Some of the lymph nodes retained the skeletons of giant follicles, but the immature lymphocytes were seen to have broken their bounds and extensively invaded the intervening tissue and the capsule, in other lymph nodes the follicular structure was entirely gone and replaced by cells, such as found in a mixed cell type lymphosarcoma. There were many giant cells and mitoses in the latter type of nodes. Often nodes revealed a mixture of the two types of structure described above. The tumor masses in the various organs had the same structure and contained the same type of cells as the lymph nodes. A skeleton follicular structure could often be seen even in the metastases in the various organs.*

Discussion—Clinically, in the differential diagnosis of follicular lymphoblastoma all the lymphadenopathies should be considered, namely

I Benign

- (a) and (b) Tuberculosis and lues. Both of these can be ruled out by the history and coexistent symptoms as well as roentgenologic findings in the case of tuberculosis, and a negative Wassermann in the case of lues.

* We are indebted to the Medical and Pathological Departments of Montefiore Hospital for permission to publish this abstract.

- (c) Mononucleosis The blood picture and the heterophile antibody reaction serve to distinguish the disease
- (d) Other acute and chronic infections—such as tonsillitis and German measles—can easily be distinguished clinically or by clinical course

II *Malignant*

(a) *Primary*

- (1) Hodgkin's disease
- (2) Lymphosarcoma
- (3) Reticulum cell sarcoma
- (4) Leukemias, aleukemic leukemias
- (5) Follicular lymphoblastoma

(b) *Secondary*

- (1) Metastases from carcinomata to the lymph nodes

A lymph node biopsy is usually necessary to make a diagnosis of one or the other of the malignant types of lymphadenopathies

Incidence of Follicular Lymphoblastoma—During the ten years, 1923–1933, 156 cases of primary malignant lymphadenopathies (not including the leukemias) were encountered in the Mt Sinai Hospital, New York City, according to Rosenthal, Harris and Kean¹⁴ The numerical distribution of these cases showed Hodgkin's disease 80 cases, lymphosarcoma 50 cases, reticulum cell sarcoma 16 cases, follicular lymphoblastoma 10 cases

Since 1925, McNee¹³ has published two cases under the title of "Sarcoma of the Spleen," Joan Ross¹⁵ published one case (Case I), in 1933, under the title of "Reticulosis with Splenomegaly," and Ferrata⁹ described one case, in 1933, all these seem to fall in the category of follicular lymphoblastoma from the macroscopic and microscopic descriptions McNee's second case seems to show a lymphosarcomatous change and was resistant to roentgenotherapy, while Joan Ross's case suggests the appearance of a chronic lymphatic leukemia

There have been, most probably, similar cases in the literature before 1925 when the first report was made by Brill, Baehr and Mandelbaum,⁴ but thus far we have been unable to discover them The report by Foix and Roemmele,¹⁰ which McNee¹³ states is similar to his and Joan Ross's¹⁵ case, seems on close examination not to be a follicular lymphoblastoma There is a proliferation of cells in the center of the malpighian bodies, but these cells seem to be, according to Foix and Roemmele's own description and illustrations, of a much more primitive type than those found in follicular lymphoblastoma They appear to be large, undifferentiated blasts with large, pale, oval nuclei containing one or more nucleoli There is also a metastasis in this case to the tissues around one adrenal

Symptomatology of Follicular Lymphoblastoma—The salient clinical features of this disease as determined by the cases reported in the literature are

- (1) Lymphadenopathy
- (2) Absence of abnormal cells in the blood, unless leukemia complicates the picture
- (3) Slight secondary anemia or no anemia and no cachexia until the latter stages of the disease
- (4) Splenomegaly, the spleen increasing in weight to 2 Kg
- (5) Absence of involvement of tonsils and the lymphatic apparatus of the gastro-intestinal tract
- (6) Tendency to lymphatic infiltration of the lacrimal gland, causing unilateral exophthalmos
- (7) Dyspnea and cough—due to pressure in mediastinal involvement
- (8) Tendency to development of serous effusions in the pleural and peritoneal cavities (due to pressure of mediastinal or abdominal lymph nodes upon venous or lymph channels⁷)

These tumors were found to be very sensitive to irradiation until the terminal stage of the disease. In several instances radium packs induced a remission when roentgenotherapy had failed.

Duration of the Disease—This is very difficult to determine as so few cases have been reported and many who are afflicted are still alive. The average duration in six patients who died of this affliction in Mt Sinai Hospital, New York City, was five years¹⁴. However, one patient is still living after 14 years, and one died after 11 years. Death has usually been due to lymphosarcomatous degeneration and generalized spread¹⁴.

Cases have been reported where only a splenomegaly was noted (Decker and Little⁶) without further lymphadenopathy. The main macroscopic and microscopic findings are described above in our report.

Follicular lymphoblastomata may be mistaken for simple follicular hyperplasia. The tremendous size of the follicles, the formation of new follicles, the occasional invasion of the capsule, and the enormous spleen differentiate the former. Joan Ross¹⁵ suggests that the difference between the two is merely a matter of the degree of hyperplasia.

In this view, Symmers^{16, 11} concurs with Ross. He reports seven cases which he calls "giant follicular lymphadenopathy with or without splenomegaly" and distinguishes them from "follicular lymphoblastoma". These cases he claims have remained stationary for years or have receded after rupture of the nodes involved. Their prognosis is good. They are supposed to show merely numerical and dimensional hyperplasia of the follicles of the involved nodes or spleen, but the normal structure of the node is maintained. The cases which are supposed to have receded have all, thus far, lived less than five years, so that recurrences may yet occur. There are, furthermore, in Symmers' paper no oil immersion photomicrographs illustrating the "giant follicular lymphadenopathy" for comparison with the oil immersion illustrations of the "sarcomatous changes in giant follicular lymphadenopathies". Therefore, we believe the evidence presented is insufficient to prove the pres-

ence of a *benign* giant follicular lymphadenopathy as yet, although such an entity may very well exist. One of Symmers' *benign* cases, reported in 1927, died some years later of Hodgkin's disease. Many others reported,^{16 II} give histories of long-standing chronic infection. One case is especially interesting because the purely intra-abdominal lymph node enlargement occurred in a case of amebic dysentery. This patient is still alive.

In the later stages of the disease, the typical picture of lymphosarcomatosis with its extreme invasiveness, and other malignant characteristics, is often seen. In one instance, an autopsy revealed only leukemic infiltration in the various organs.^{16 II} Another, according to Klempeier,¹² developed a blood picture characteristic of chronic lymphatic leukemia. The necropsy of this case revealed a spleen typical of this affliction. All lymph nodes were enlarged discretely, except in the pancreatic region where infiltration of the capsule and the surrounding areolar tissue was seen. A third case, that of Joan Ross,¹⁵ also suggested the presence of leukemia. Finally the bone marrow findings in our case proved conclusively the presence of chronic lymphatic leukemia, as did the peripheral blood findings taken at the same time as the bone marrow biopsy.

A distinct contribution to the understanding of the follicular lymphoblastoma disease entity in Symmers'^{16 II} article is the reporting, for the first time in the literature, of typical cases with mutation to Hodgkin's disease. Of the seven cases of this presented, especially the second (Part III, Case 2) is impressive, one node showing the typical picture of follicular lymphoblastoma in one part and typical Hodgkin's changes in another. Also reported by Symmers is a case of follicular lymphoblastoma with leukemic blood changes in which, after death, there were *no lymphosarcomatous changes found*—only leukemic infiltrations in liver, spleen, stomach, adrenals and all superficial and deep nodes.

The determination of the exact position of follicular lymphoblastoma among the many entities of the lymphoblastoma group is difficult. The first stage appears to be a proliferation in germ centers of lymph nodules, of the cells with large hypochromatic nuclei, termed reticulum cells by most observers, with some differentiation toward lymphocytic cells. Changes to pure leukemia, pure Hodgkin's, lymphosarcoma or a mixture of lymphosarcoma and leukemia have then followed. Follicular lymphoblastoma may, therefore, be the starting point for all three of the above mentioned diseases. The direction of the changes would then be dictated by the various unknown causes of the reticulosis.

To complicate the picture, some evidence of the relationship between lymphadenosis and lymphosarcomatosis has been furnished by the experiments of Furth¹¹ and his co-workers. They have produced, in mice, both these diseases by the injection of one type of pathologic lymphocyte. Intravenous injections of these cells caused leukemia, while subcutaneous injections of the same cells caused lymphosarcomatosis. There were also strains of mice in which both lymphosarcomatosis and leukemia resulted from one injection subcutaneously.

of pathologic cells. Although the conclusions from these experiments cannot, without further proof, be directly applied to human beings at present, they point to the closeness of the two processes. The experiments of Furth were well controlled and the number of spontaneous leukemias arising relatively small. Also, there have been cases reported with leukemic blood pictures which histologically showed changes of Hodgkin's type.¹⁷

Whether the leukemias, follicular lymphoblastomata and lymphosarcomata are to be regarded as strictly malignant growths is still disputed. Klemperer states "Experience seems to point to a close affinity between the simple hyperplastic and neoplastic proliferations of the lymphatic system. It is necessary to state, however, that the generalization of the cellular proliferation militates against the rigid identification of either lymphadenosis or lymphosarcomatosis with malignant neoplasms." However, certainly lymphosarcomatosis shows all the basic criteria of true malignancies. The differences in its method of spread and its multiple growth foci may be peculiarities of tumors of a hemopoietic system. Even in lymphadenosis, there are metastases, often capsular infiltration and the presence of all types of nuclei, so that this disease can, likewise, be considered as truly malignant. At any rate it is again to be stressed that the border line between the simple hyperplasias and malignancy is by no means sharp.

SUMMARY

A report of a case of follicular lymphoblastoma is given, with a pathologic description of the spleen and of a lymph node removed at operation. A discussion of the literature is undertaken, and of the peculiar position of this disease in relation to the leukemias and the lymphoblastoma group.

REFERENCES

- ¹ Baehr, G. Clinical and Pathological Picture of Follicular Lymphoblastoma. *Trans Assoc Amer Phys*, 47, 330, 1932, or *J A M A*, 99, 254, 1932.
- ² Baehr, G., Klemperer, P., and Rosenthal, M. Follicular Lymphoblastoma. *Amer Jour Path*, 7, 558, 1931.
- ³ Baehr, G., and Rosenthal, N. Malignant Lymph Follicle Hyperplasia of Spleen and Lymph Nodes. *Amer Jour Path*, 3, 550, 1927.
- ⁴ Brill, N. E., Baehr, G., and Mandelbaum, N. Giant Lymph Follicle Hyperplasia of Lymph Nodes and Spleen. *J A M A*, 84, 668, 1925.
- ⁵ Callender, G. R. Tumors and Tumor-Like Conditions of the Lymphocyte, the Myelocyte, the Erythrocyte and the Reticulum Cell. *Amer Jour Path*, 10, 447, 1934.
- ⁶ Decker, H. R., and Little, H. G. Giant Follicular Hyperplasia of the Lymph Nodes and Spleen. *J A M A*, 105, 932, 1935.
- ⁷ Ehrlich, J. C., and Gerber, J. E. The Histogenesis of Lymphosarcomatosis. *Amer Jour Cancer*, 24, 1, 1935.
- ⁸ Ewing, H. M., and Fein, J. Follicular Lymphoblastoma with a Brief Review of the Literature. *J Lab and Clin Med*, 22, 807, 1937.
- ⁹ Ferrata, A., and Introzzi, P. Splenomegalia Primitiva Folliculo-Iperplastica. *Splenectomia—Guarigione*. *Hematologica I*, 14, 159, 1933.
- ¹⁰ Fox, C., and Roemmele, A. *Arch de Med Exper et d'Anat Path*, 24, 111, 1912.
- ¹¹ Furth, J., Seibold, H. R., and Rethbone, R. R. Experimental Studies on Lymphomatosis in Mice. *Amer Jour Cancer*, 19, 521, 1933.

- ¹² Klemperer, P The Spleen in Hodgkin's Disease, Lymphosarcomatosis and Leukemia
Amer Jour Med Sci, 188, 593, 1934
- ¹³ McNee, J W Sarcoma of the Spleen Jour Path and Bact, 39, 83, 1934
- ¹⁴ Rosenthal, N, Harris, W, and Kean, A Clinical and Radiotherapeutic Considerations
of Follicular Lymphoblastoma Amer Jour Roentgen, 29, 95, 1933
- ¹⁵ Ross, Joan M The Pathology of the Reticular Tissue Illustrated by Two Cases of
Reticulosis with Splenomegaly and a Case of Lymphadenoma Jour Path and Bact,
37, 311, 1933
- ¹⁶ Symmers, D (I) Follicular Lymphadenopathy with Splenomegaly Arch Path, 3,
550, 1927
(II) Giant Follicular Lymphadenopathy With or Without Splenomegaly
Arch Path, 26, 603, 1938
- ¹⁷ Downey Handbook of Hematology 4, 3074-3098, 1938, Chapter by Watson Concern-
ing Transitions Between Hodgkin's Disease and Leukemia

THE TREATMENT OF COMPOUND FRACTURES OF THE LONG BONES*

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THERE are few conditions in the field of surgery which place a greater premium on surgical judgment and experience than the treatment of compound fractures and their complications. Each case must be a law unto itself. Nevertheless, it seems worth while to offer an outline for treatment, which is based upon experiences at the Beekman Street Hospital. The emphasis for proper management is illustrated rather by the mistakes and failures than upon the good results, in the belief that it is more profitable to critically examine our shortcomings than our successes. The material upon which this study is based covered all the cases of compound fractures of the extremities which were at the Beekman Street Hospital from 1925 to 1936, inclusive, whose original treatment was received there. There were 128 patients, two of whom had compound fractures of an upper and lower extremity simultaneously, 34 patients with compound fractures of the upper and 94 of the lower extremity. The only cases eliminated were those whose initial treatment was received elsewhere, or those in which the compound fractures were confined to the bones distal to the ankle or wrist joints.

A review of the causation of these injuries is a ghastly comment on our careless disregard for life and limb. Most of the injuries are preventable, but can be reduced only by education of the public, industrial management, and the management and supervision of buildings. Aside from the tragedies to the individual and his dependents, an enlightened self-interest on the part of the commonwealth, industry, and real estate will pay dividends in dollars and cents.

The treatment of compound fractures properly begins at the site of injury and with the transportation to the hospital. This phase of treatment, as practiced at the Beekman Street Hospital, has been adequately covered recently by Kennedy^{1, 2} and Findlay³.

The patient arrives at the emergency room in traction, which is maintained. If shock is present, or, if not in shock, if the injury is of sufficient severity as to suggest that shock will supervene, intravenous saline is administered at once in the emergency room, blood is taken for typing, 3,000 units of tetanus antitoxin are injected intramuscularly, and external heat is applied. If bleeding is severe, it is controlled by a tourniquet, which is loosed every 20 minutes and immediately reapplied if bleeding recurs. Roentgenograms

* Read before the New York Surgical Society, March 8, 1939. Submitted for publication February 8, 1939.

are taken later on the way to the ward, where the shock treatment is continued, if necessary

The first consideration is given to the patient's general condition. This should include, in addition to the presence of the signs and symptoms of shock, a careful survey of the local and complicating injuries, age and general condition. In traffic injuries, fractures of the skull and intracranial injuries, rib or pelvic fractures, and visceral injuries are common, in addition to the compound fractures of the extremities. In falls from a height, fractures of the spine, with or without cord lesions, should be looked for. If serious injuries are overlooked, operation for the local condition may be undertaken when a fatal outcome is inevitable, or, worse, the failure to evaluate the more serious condition which is amenable to treatment may result in death from that complication, or the débridement may add sufficient shock to tip the scales the wrong way.

In severe injuries of this type, a considerable immediate mortality is unavoidable. Possibly an occasional case could be saved, if a blood bank were available for an immediate transfusion, but it is doubtful whether much improvement would occur. Immediate infusion has been the greatest advance in lowering the mortality in these desperate cases during the past three decades.

Thirteen patients died within the first 36 hours after admission, whose condition and the nature of whose injuries were such as to render a fatal outcome inevitable and upon whom no operative procedures were attempted. It is noteworthy that all received infusions, although one died within 15 minutes after admission. Five of these patients died within one hour of admission and only one lived over 24 hours, death occurring 36 hours after admission. These cases are hopeless from the start, and are a surgical problem only insofar as the recognition that any operation is contraindicated.

For the sake of the record it should be stated that one of these cases (No 10) had a ruptured ileum, which was unrecognized until autopsy. As he was 80 years of age and suffering, in addition to a compound fracture of the right tibia and fibula, fractures of the left tibia and fibula, right ilium, the fifth, sixth and seventh ribs, concussion of the brain, and acute alcoholism, it is unlikely that that oversight would have altered the outcome.

We have touched on the question of debridement in the presence of serious complications. There is no question as to the advisability of debridement *per se* in compound fractures. There is, however, a difficult problem as to when and how a debridement should be performed.

The question of time is the most difficult for the surgeon. Obviously, as far as avoiding infection is concerned, the sooner the better. In the presence of shock debridement should be withheld, and, if delay is protracted, it becomes a useless and harmful procedure. The question must be answered as to how long after injury débridement has any value.

Consideration of when débridement is performed, is dependent upon the

TABLE I

RESUME OF FATALITIES OCCURRING WITHIN 36 HOURS AFTER ADMISSION

Without Operation

Case No	Hosp No	Sex	Age	History, Diagnosis, Course and Cause of Death	
1	13771	M	2 yrs	Adm 5/11/30	Fell four stories Treatment of shock, therapeutic spinal taps (3), fluid grossly bloody Died 12 hours after admission <i>Diagnosis</i> Compound fracture left elbow, laceration of brain, fracture of skull <i>Cause of Death</i> Cerebral injuries, shock
2	8066	M	Adult	Adm 10/23/27	Fell from window Treatment of shock Died one hour after admission <i>Diagnosis</i> Compound fracture of skull, compound fracture left humerus (lower third), fracture of right femur (lower third), laceration of brain, shock <i>Cause of Death</i> Cerebral injuries, shock
3	9466	M	70 yrs	Adm 6/14/28	Automobile injury Treatment of shock Died one hour after admission <i>Diagnosis</i> Compound fracture left humerus, compound fracture left radius and ulna, fracture of skull, fracture of right femur, avulsion of soft parts of right leg and foot <i>Cause of Death</i> Shock
4	8715	F	80 yrs	Adm 2/7/28	Bus ran over right leg Treatment infusion and transfusion (450 cc) Died suddenly 18 hours after admission <i>Diagnosis</i> Compound fracture right tibia and fibula, middle third, laceration of scalp <i>Cause of Death</i> Embolus, shock
5	10046	M	44 yrs	Adm 9/25/28	Crushed under bags of flour Treatment of shock Systolic blood pressure 70 at time of admission, 110 in one hour and then fell rapidly Pulse at time of admission 120, then rose to 140 Respiration 36 Increasing cyanosis and dyspnea Died two hours after admission <i>Diagnosis</i> Compound fracture of tibia and fibula, lower third, right and left, fracture fourth and fifth ribs, left, laceration of lung <i>Cause of Death</i> Laceration of lung, shock
6	9562	M	50 yrs	Adm 6/28/28	Struck by elevated train Treatment of shock Died 14 hours after admission <i>Diagnosis</i> Compound fracture of tibia, internal condyle, right, crushing injury to chest, fracture second and sixth ribs, left <i>Cause of Death</i> Chest injury, shock
7	12419	M	25 yrs	Adm 10/11/29	Struck by train Treatment of shock Died 20 minutes after admission <i>Diagnosis</i> Compound fracture of lower third of left femur, traumatic amputation of left forearm, upper third, avulsion of soft parts of left foot, shock <i>Cause of Death</i> Hemorrhage, shock

COMPOUND FRACTURES

TABLE I (*Continued*)

Case No	Hosp No	Sex	Age	History, Diagnosis, Course and Cause of Death	
8	12241	M	Adult	Adm 9/13/29	Fell six stories to wire netting Treatment of shock Died nine hours after admission <i>Diagnosis</i> Compound fracture of right tibia and fibula, lower third, compound fracture of left fibula, lower third, intra-abdominal injuries <i>Cause of Death</i> Internal injuries, hemorrhage
9	24414	M	55 yrs	Adm 9/1/34	Automobile ran over both legs Treatment of shock Died 19 hours after admission <i>Diagnosis</i> Compound fracture of left tibia and fibula, middle third (nearly amputated), compound fracture right tibia and fibula, upper third, avulsion of soft parts of right leg, shock <i>Cause of Death</i> Shock
10	24807	M	80 yrs	Adm 11/7/34	Struck by automobile Treatment of shock, traction-Kirschner wires Died 24 hours after admission <i>Diagnosis</i> Compound fracture right tibia and fibula, middle third, compound fracture left tibia and fibula, upper third concussion of the brain, fracture of the right ilium, fracture of the fifth and seventh ribs, left, rupture of the ileum, peritonitis, alcoholism (Ruptured ileum was an autopsy finding, not previously suspected) <i>Cause of Death</i> Peritonitis, shock
11	27296	F	50 yrs	Adm 12/23/35	Fell five stories Treatment of shock, traction-Kirschner wire left os calcis, Russell traction to right femur Died 36 hours after admission <i>Diagnosis</i> Compound fracture of left tibia and fibula, lower third, fracture right ilium, fracture right humerus, upper third, fracture right femur, upper third, fracture sternum, fracture of ribs, right and left, hemothorax (bilateral), acute alcoholism, shock <i>Cause of Death</i> Shock, chest injury
12	15036	M	Adult	Adm 11/22/30	Struck by elevated train Treatment of shock Died 15 minutes after admission <i>Diagnosis</i> Compound fracture of right femur, lower third, compound fracture left tibia and fibula, lower third, compound fracture of skull, laceration of brain, fracture of second, third, fourth and fifth metacarpals, left <i>Cause of Death</i> Cerebral injuries, shock
13	14470	F	68 yrs	Adm 8/30/30	Fell from third story Treatment of shock, skin traction to leg, 20 pounds Died 45 minutes after admission <i>Diagnosis</i> Compound fracture of right femur, middle third, fracture of skull, laceration of brain, fracture of mandible, laceration of tongue <i>Cause of Death</i> Cerebral injuries, shock

patient's ability to withstand the added trauma and shock. The question of complicating, more imperative injuries has been mentioned. If the other injury in itself is fatal, a debridement is evidence of poor judgment. It is equally true, that if the complication is amenable to treatment, and of a more urgent nature than the compound fracture, the complication should receive first attention. The former is the more frequently encountered. However, occasionally a ruptured viscus, hemopericardium, extradural hemorrhage, a ruptured lung, or bleeding into the pleura may be amenable to treatment without the added shock of debridement. The presence of shock most frequently enforces delay in surgical treatment. It must be borne in mind that delayed shock is a common occurrence when patients are brought to the hospital promptly after injury. It has been our rule not to operate upon a patient whose systolic blood pressure is under 80 Mm. Obviously, a blood pressure of 80 in an elderly adult is much more significant than in a child or young adult. If, on arrival, a patient is not apparently shocked, but the injuries are sufficiently severe as to indicate that shock may supervene, treatment for shock is continued and the patient is kept under close observation, with pulse and blood pressure readings at 30-minute intervals, and operation held in abeyance. In order to lessen fatalities and improve results, it would seem fair to consider a fatality within 24 hours, or less, of a debridement as an error of judgment on the part of the operator.

There were nine deaths within 24 hours after débridement. In one case (No. 4) chest and cerebral injuries were overlooked, which if recognized would have contraindicated operative procedure. One case (No. 8) was complicated by delirium tremens and was debrided and closed 23 hours after admission, and died 12 hours later. There is nothing to be said in extenuation of the latter. Acute alcoholism was a factor in three cases. This factor must be taken into consideration, and in its presence surgical procedures should be limited to the minimum. Of the medical complications, Case No. 2, with a preoperative blood pressure of 184/134 in the face of a shocking injury, might have been a warning against operative interference. It is only fair to state that it is questionable whether any of these fatalities would have been avoided had they been handled differently.

We have left patients in emergency traction and even continued the tourniquet for over 12 hours without regrets. Such a procedure is not justifiable for the convenience of the operator. If used, close attention must be given to the circulation in the extremity, especially since it may already be compromised by the injury.

Debridement having been delayed by the patient's condition, the question arises how long the procedure has any value. After six hours, even in the presence of gross contamination, a debridement would tend to mobilize rather than prevent the spread of infection. Removal of foreign bodies, thorough drainage, and gentle irrigation is a more rational treatment at that time.

Technic of Debridement—If it does not interfere with the exposure of

COMPOUND FRACTURES

TABLE II

RÉSUMÉ OF FATALITIES OCCURRING WITHIN 24 HOURS AFTER ADMISSION

After Débridement

Case No	Hosp No	Sex	Age	History, Diagnosis, Course and Cause of Death
1	21761	M	51 yrs	Adm 7/10/33 Automobile ran over right forearm Intoxicated for the past three weeks, exposure Treatment of shock, operation—débridement and closure, duration of operation one hour, ether anesthesia used, preoperative blood pressure 90 Died 15 hours after operation <i>Diagnosis</i> Compound fracture of right ulna, upper third, crushing of soft parts of right forearm, avulsion of the skin of the right arm and forearm, shock, fatty liver, congestion of the lungs (autopsy) <i>Cause of Death</i> Shock and preoperative general condition
2	21815	M	52 yrs	Adm 7/18/33 Fell 20 feet down elevator shaft Treatment of shock, preoperative blood pressure 184/134, operation—debridement and closure, duration of operation one hour and ten minutes, ulnar nerve sutured Blood pressure unobtainable postoperatively Acute dilatation of the abdomen Died five hours after operation <i>Diagnosis</i> Compound fracture internal condyle of right humerus, division of ulnar nerve, right, fracture of third, fourth and fifth metacarpals, left, fracture of fibula, left malleolus, fracture and dislocation of left calcaneus <i>Cause of Death</i> Shock and cardiac decompensation
3	6339	M	45 yrs	Adm 1/20/27 History unknown Treatment of shock, operation—debridement, not sutured, Steinman pin, traction Died five and one-half hours after admission <i>Diagnosis</i> Compound fracture of right tibia and fibula, lower third, fracture of skull, laceration of the brain, acute alcoholism <i>Cause of Death</i> Shock and cerebral injuries
4	12943	M	34 yrs	Adm 1/7/30 Struck by automobile Treatment of shock, operation—débridement, gas-oxygen anesthesia used, Steinman pin, traction Died eight and one-half hours after operation <i>Diagnosis</i> Compound fracture left tibia and fibula, upper third, fracture of skull, fracture of sternum, fractured ribs <i>Cause of Death</i> Cerebral and chest injuries Operation was ill-advised Injuries other than leg unrecognized
5	16179	M	56 yrs	Adm 5/13/31 Fell 12 feet into elevator shaft Treatment of shock, operation—débridement without closure, Steinman pin, duration of operation 45 minutes Patient was restless and noisy following operation Morphine, grains 1/6, was given at 9 35 P M, and hyoscin, grains 1/150, at 9 50 P M Death occurred 35 minutes later Died 5 hours after operation <i>Diagnosis</i> Compound fracture of left tibia and fibula, lower

TABLE II (*Continued*)

Case No	Hosp No	Sex	Age	History, Diagnosis, Course and Cause of Death
				third, shock, cardiac hypertrophy, sclerosis of the coronary artery, general arteriosclerosis, chronic nephritis (autopsy) <i>Cause of Death</i> Shock and cardiovascular condition Hyoscine may have contributed
6	22459	M	38 yrs	Adm 10/27/33 Coal truck passed over left lower extremity Treatment of shock, operation—débridement without closure, four hours after admission, adhesive traction, 20 pounds, transfusion (500 cc) and gas gangrene antitoxin, in addition to continuous infusion Distention of the abdomen Died 10 minutes after a gastric lavage (not due to asphyxiation) Died 20 minutes after operation <i>Diagnosis</i> Compound fracture of left tibia and fibula, upper third, fracture of left tibia, medial condyle, crushing of muscles of thigh and leg, left, fracture of left femur, medial condyle, anaerobic infection <i>Cause of Death</i> Shock
7	18545	M	60 yrs	Adm 4/10/37 Run over by truck Treatment of shock, operation—disarticulation of the left leg at the knee, debridement of right leg, packed open, Steinman pin (Seven hours after admission, due to patient's refusal of consent) Died two and one-half hours after operation <i>Diagnosis</i> Compound fracture of left tibia and fibula, lower third, avulsion and crushing of skin and muscles, left leg, compound fracture of right tibia and fibula, lower third, compound fracture of right calcaneus, compound fracture right talus, shock At autopsy, edema of lungs, sclerosis of coronary artery, chronic nephritis and chronic pulmonary tuberculosis were found <i>Cause of Death</i> Shock
8	12466	M	40 yrs	Adm 10/18/29 Truck ran over right leg Acute alcoholism Delirium tremens Treatment of shock, sedation, fixed traction maintained, operation—debridement and closure, Tong traction (Operation 23 hours after admission) Systolic blood pressure 110 Died 12 hours after operation <i>Diagnosis</i> Compound fracture right femur, middle third, crushing injury right thigh, acute alcoholism, sepsis of right leg (autopsy) <i>Cause of Death</i> Shock and sepsis Operation ill-advised
9	3402	M	21 yrs	Adm 4/17/25 Run over by a street car Treatment of shock, operation—amputation of thigh completed, vessels tied, T-binder applied and packed for evisceration Duration of operation 25 minutes Died seven hours after operation <i>Diagnosis</i> Traumatic amputation of left thigh, upper third (nearly complete), tear of rectum, partial evisceration through rectal tear <i>Cause of Death</i> Shock

the operative field, the original traction is maintained by the Thomas type splint. Otherwise the splint is removed in the operating room and continuous traction maintained by an assistant. The operative field is shaved and 3-5 per cent iodine applied as for any operative procedure, including the cut edges of the skin. Whether or not iodine is applied in the wound is not important, but does no harm. Irrigation with large quantities of normal saline under moderate pressure (four to six feet) is performed, the flow being from within the wound. During the irrigation the wound is gently scrubbed with green soap toward the edges, removing such gross contamination as is not fixed in the soft parts. This is followed by irrigation with ether. The skin and extremity are dried and repainted with iodine. If the operating table is wet and drapes have become wet, they can no longer be considered sterile. The wound is draped and the skin surface covered. Grossly contaminated or nonviable tissues, and small loose fragments of bone are excised by sharp dissection. Bleeding points are ligated. Only essential structures, such as tendons and nerves, are sutured, and the wound is packed open with vaselined gauze. If infection seems probable, Dakin tubes are introduced at that time. If there is marked avulsion of skin it may be partially sutured with loose, interrupted sutures. The use of local infiltrating anesthesia is contraindicated in such wounds, because of the danger of spreading infection.

The careful layer suture of tissues and closure of such wounds is counseled against. When successful, it lessens scarring and prevents later contamination from the outside. On the other hand, the infection rate is high, 48 per cent in the lower extremity and 41 per cent in the upper extremity in this series. When infection supervenes in such a wound, serum and old blood are walled-off, pressure is increased, necrosis of undamaged tissues occurs, drainage is inadequate, and spread of the infection is facilitated. The danger of sepsis and even the functional result is definitely poorer when infection occurs after layer closure. Most of us have been converted to leaving wounds about drains open in such cases as peritoneal abscesses. The improvement in the healing of such wounds, and the lowered incidence of postoperative hernia are indisputable. It is more important in compound fractures because of sepsis and to lessen the occurrence of osteomyelitis. The introduction of any sutures, even the repair of tendons and nerves, should be the exception and not the rule.

The dangers of contamination of freely drained wounds from the outside are minimal. We have all seen joints, tendon sheaths and the medullary cavities of long bones opened through infected fields, either inadvertently or through mistakes in diagnosis, and I can recall few instances of serious infection resulting when such incisions are left open. One is forced to wonder whether the so-called low resistance of such tissues to infection is not a mechanical or anatomic defect, rather than any intrinsic susceptibility of the tissues themselves.

The treatment of the fractures will only be touched upon briefly and in

a general way If the fracture is of such a nature that it can be maintained by plaster encasement, with immobilization of the joints above and below the fracture, that treatment is preferable to prevent infection, and if infection occurs, to prevent its spread, as advocated by Orr,⁴ and Pfeiffer and Smyth.⁵ Unfortunately, most of the fractures of the long bones require traction to prevent overriding. In addition, the extent and nature of the wounds may be such as to require easy access for inspection and treatment. In such cases and in cases potentially infected with anaerobic organisms, the use of Russell and Blum traction for the upper extremities and pin traction for the lower extremities best answers the requirements.

Manipulation of compound fractures is fraught with great danger of spreading infection. It is important, therefore, to obtain at the original debridement good reduction, and to maintain the reduction. When infection is present, no further attempt should be made at manual reduction, even though malunion or even nonunion appears likely. Good reduction, which may result in the loss of the limb or even life, may reward such efforts. We have not employed foreign material such as Lane plates in potentially infected wounds, and bone grafts are obviously contraindicated.

Amputation—We are probably on the conservative side, and will probably continue so, in not advocating early amputation. It is felt that almost any limb, particularly a lower extremity, is preferable to an artificial limb. As a result, except where the circulation is hopelessly impaired, amputation is not performed early as a rule, and on occasion it is regretted. There are cases of dirty, crushing injuries with severe damage to soft tissues in which immediate amputation is a life-saving procedure, or will prevent prolonged sepsis and disability with a functionless extremity. The surgeon should be alert in recognizing such cases and acting promptly.

There were only five cases in which amputation was performed as the immediate operative treatment. By immediate, it should be understood that they were performed as soon after admission as the operator felt that their condition was sufficiently good to withstand the added shock, and all were performed within 24 hours of admission. The two upper extremities (No. 1 and No. 2) were amputated at the site of the highest fracture and left open, requiring later revision of the stump. Two of the lower extremities (No. 3 and No. 5) were disarticulated through the knee joint, as it was considered that they would not survive an amputation of election. The other lower extremity amputation, a compound fracture of the lower third of the leg, was amputated at the site of injury. This resulted in the longest hospitalization, four months, and a stormy course, but preserved the knee joint. Amputation was performed in four of these cases because of extensive soft part injuries. The other was performed because of compromise of the circulation. There was only one death in this series, No. 5, which occurred two and one-half hours postoperatively.

COMPOUND FRACTURES

TABLE III

RESUMÉ OF CASES HAVING IMMEDIATE AMPUTATION

Case No	Hosp No	Sex	Age	History, Diagnosis, and Course
1	16455	M	39 yrs	Adm 6/24/31 Right forearm crushed between car and truck Treatment of shock, amputation performed on 6/24/31 of lower third of right arm Wound left open Mixed infection followed Patient discharged 7/21/31 <i>Diagnosis</i> Compound fracture of right radius and ulna, upper third, crushing injury of right forearm, fracture of right humerus, lower third, shock On 5/18/32 the stump was well healed and patient was wearing an artificial arm
2	4034	M	Adult	Adm 10/1/35 Right arm crushed in printing press Treatment of shock for 24 hours, 10/2/35, operation—amputation of right arm, lower third, and wound left open 10/20/35, revision of amputation stump with closure Wound healed without infection Patient discharged 10/31/35 <i>Diagnosis</i> Compound fracture of right humerus, supracondylar, compound fracture of right radius and ulna, middle third, compound fracture of carpal and metacarpal bones, right, dislocation of elbow, right, lacerations, maceration, and avulsion of the skin of the forearm and lower fourth of right arm, shock
3	6406	M	9 yrs	Adm 1/29/27 Truck ran over right leg Treatment of shock, two transfusions first 24 hours 1/30/27, poor circulation, gangrene, 2/1/27, operation—disarticulation at right knee joint, perfringens serum, 2/21/27, operation—amputation of lower third of right thigh, 3/21/27, stump nearly healed Discharged 3/21/27 4/20/27, superficial abscess opened 10/19/27, stump well healed <i>Diagnosis</i> Compound fracture of right femur, lower third, crushing injuries with laceration into knee joint, later, gangrene right leg (circulatory with infection), anaerobic infection
4	11180	M	27 yrs	Adm 4/5/29 Right leg crushed between elevator and floor Treatment of shock 4/5/29, operation—amputation at site of fracture No closure Severe infection, necrosis of tissues and sepsis ensued 6/21/29, revision of amputation and closure middle and upper third of leg, infected, re-opened 7/17/29, skin graft 8/3/29, nearly healed Small granulating area Patient discharged 8/3/29 4/15/31, stump well covered and healed Walking with artificial limb <i>Diagnosis</i> Compound fracture of right tibia and fibula, lower third, avulsion and maceration of soft parts of lower third of right leg
5	18545	(See Case No 7, Table II)		

Late amputations, as a rule, were performed for spreading infections, or impaired circulation, or a combination of the two In lower leg injuries,

when sepsis and the preservation of life is the indication, and infection has spread above the fracture site, amputation through the knee is usually performed. This causes little shock and opens the least avenue for spread of the infection. Amputation through the elbow is equally applicable for forearm injuries. While it requires a later reamputation, it can be best borne by the weakened, septic patient. The later amputation can be postponed until he has regained his strength, at which time the operation can be performed without danger of infection and at the site of election. When the infection is better localized below the site of the fracture, or the circulation is impaired at that site, we prefer guillotine amputation at the fracture site, the stump left open, and a late revision at the site of election. It is a temptation in such cases to amputate the bone above the fracture to avoid a reamputation. It should be remembered, however, that there is a defense reaction in the medulla of the bone, just as there is in soft tissues. Especially in *Streptococcus* infections, there is danger of lighting up and spreading the infection by that procedure, nor does higher division of the bone prevent infection of the bone at the site of amputation.

There were 11 cases upon whom amputations were performed late for the preservation of life, with a single mortality. As one case had an amputation through both thighs, 12 limbs were sacrificed. Seven amputations were required for severe, spreading infections, two were performed for circulatory impairment, and three were for a combination of both. Of the nine lower extremity amputations, five were disarticulated at the knee, three of the thigh and one of the leg were left open. Only one of the three amputations of the forearm was closed and that became infected. While nearly all of these cases required later revisions, we attribute the low mortality to the stage-operations, and the conservatism shown in leaving the wounds open. Six of these infections, including the fatal case, were anaerobic infections clinically (Table IV).

TABLE IV

RÉSUMÉ OF CASES HAVING LATE AMPUTATION

Case No	Hosp No	Sex	Age	History, Diagnosis and Course
1	5996	M	31 yrs	Adm 11/13/26 Struck by truck while riding motorcycle Treatment of shock, transfusion, Steinman pin, calcanus traction (10 pounds), reduction of dislocation of shoulder 11/16/26, dry gangrene of toes, circulatory 11/24/26, operation—amputation through right knee joint, infection above knee 12/30/26, operation—amputation middle third of right thigh, closure Discharged 1/19/27, with wounds nearly healed <i>Diagnosis</i> Compound fracture of right tibia and fibula, upper third, laceration right thigh, dislocation of shoulder, right, shock Amputation lower third of right thigh for impaired circulation and infection

COMPOUND FRACTURES

TABLE IV (Continued)

Case No	Hosp No	Sex	Age	History, Diagnosis and Course
2	9462	M	Adult	Adm 6/14/28 Fell one floor down elevator shaft Treatment of shock, 6/14/28, operation—débridement and closure, drained, Steinman pin, traction (25 pounds, later 15 pounds) 6/16/28, wound infected (anaerobic), opened, transfusions (3), perfringens serum 6/20 and 6/21/28, reoperations for drainage 7/8/28, operation—amputation, disarticulation through knee joint 8/3/28, incision and drainage of thigh 9/1/28, guillotine amputation of thigh, lower third, open 9/26/28, operation—revision of amputation of stump, suture, infection 10/13/28, patient discharged Small granulating wound <i>Diagnosis</i> Compound fracture of left tibia and fibula, lower third Amputation of lower third of thigh for anaerobic infection
3	10580	M	19 yrs	Adm 1/3/29 Left thigh crushed between elevator and floor Treatment of shock, systolic blood pressure 85, transfusion 500 cc, wound packed for hemorrhage, maximum traction 1/5/29, wound opened, anaerobic infection, perfringens serum 1/6/29, transfusion 500 cc, 1/8/29, operation—amputation of left thigh, middle third, open, transfusion 500 cc Died 12 hours after operation <i>Diagnosis</i> Compound fracture left femur, middle third, crushing wound of thigh, shock Amputation for sepsis
4	12408	M	53 yrs	Adm 10/9/29 Box, weight one ton, fell on right leg Treatment of shock, Thomas splint applied 10/10/29, Steinman traction, 10/16/29, infection (<i>Staphylococcus aureus</i>), 12/7/29, operation—amputation upper third of right leg, open, 1/18/30, reamputation of stump, closure, 1/30/30, opened, infection, 2/3/30, patient discharged with draining wound <i>Diagnosis</i> Compound fracture of the right tibia and fibula, lower third, fractured calcaneus, fractured talus, crushing of lower third of right leg and ankle, shock
5	29167	M	45 yrs	Adm 11/19/36 While cranking truck, it backfired and crank handle struck right wrist Treatment 11/19/36, operation—debridement and closure, closed reduction and plaster splints Local infiltration anesthesia used 11/20/36, closed reduction (ether) 11/24/36, infection (nonhemolytic <i>Streptococcus</i>) Temperature 103° to 105° F the first week of septicemia Reduction by lysis to normal in seven weeks Thrombophlebitis of right femoral vessels Transfusions Incisions and drainage of wrist and forearm 12/31/36, amputation at fracture site for osteomyelitis of radius, carpal and metacarpal bones and suppurative arthritis of joints of wrist Radius and ulna amputated three inches above fracture No closure Recrudescence of fever less severe for seven weeks more and infection of bone ends 3/20/37, patient discharged

TABLE IV (Continued)

Case No	Hosp No	Sex	Age	History, Diagnosis and Course
6	20448	M	40 yrs	<i>Diagnosis</i> Compound fracture of right radius, Colles, laceration of ulnar volar region of right wrist Amputation of right forearm, middle third, for sepsis
				Adm 12/30/32 Left arm caught in machine Treatment Operation—débridement and closure, Kirschner wire through olecranon, traction Thrombosis radial artery Dry gangrene of fingers 1/10/33, amputation upper third of left forearm, open (circulatory impairment), 2/4/33, reamputation upper third of left arm, closure (high amputation for paralysis of shoulder-brachial plexus tear), 2/9/33, discharged with amputation wound clean
7	3037	M	Adult	<i>Diagnosis</i> Compound fracture left humerus, middle third (protrusion of lower fragment), laceration of brachial plexus, thrombosis or tear of radial artery Amputation for impaired circulation
				Adm 1/12/25 Caught hand in vacuum machine Treatment Operation—débridement and drainage, 1/12/25, 1/22/25, infection Incision and drainage Gangrene two inches above wrist, 1/23/25, amputation middle third of forearm, sutured and drained Discharged 3/3/25 Still slight drainage
8	23136	M	44 yrs	<i>Diagnosis</i> Compound fracture and dislocation of right carpus, compound fracture of right radius and ulnar styloids, division of extensor pollicis longus, maceration of wrist Amputation middle third of right forearm for infection and circulatory impairment
				Adm 2/23/34 Truck ran over right leg Treatment 2/23/34, operation—débridement and closure, dakinized, plaster, 2/24/34, Kirschner wire traction (10 pounds), temperature 103° F, infection 2/25/34, anaerobic infection, perfringens serum 2/27/34, disarticulation of right knee 3/12/34, temperature normal 3/23/34, amputation of lower third of right thigh, closed 4/4/34, sutures removed, wound clean 4/11/34, drainage 5/5/34, patient discharged Wounds healed
9	13468	M	24 yrs	<i>Diagnosis</i> Compound fracture of right tibia and fibula, middle third, crushing of soft parts, avulsion of skin Amputation of lower third of right thigh for anaerobic infection
				Adm 3/27/30 Fell 30 feet Treatment for shock, operation—débridement, open, dakinized (Amputation advised and refused) 4/2/30, anaerobic infection Operation—amputation of thigh, lower third, open 4/22/30, revision of amputation, closed 5/13/30, patient discharged Seen 9/17/30, and found to have a draining, sinus 2/28/31, has been wearing an artificial leg since December 11/7/33, leg has remained healed 11/7/33, patient discharged
				<i>Diagnosis</i> Compound fracture of right tibia and fibula
				482

COMPOUND FRACTURES

TABLE IV (Continued)

Case No	Hosp No	Sex	Age	History, Diagnosis and Course
				upper third, laceration of right knee joint, fracture internal condyle of right tibia
				Amputation of lower third of right thigh for anaerobic infection
10	16395	M	43 yrs	Adm 6/15/31 Iron girder fell across both legs Treatment of shock, right tibial wound packed for hemorrhage, adhesive traction to both legs Right leg cold and pulseless 6/16/31, transfusion and shock treatment 6/17/31, legs livid 6/20/31, operation—disarticulation of right leg at knee (circulatory gangrene) 6/22/31, amputation of left thigh, lower third (anaerobic infection and circulatory impairment), open Transfusions and perfringens serum 7/6/31, incision and drainage of abscess in sacral region 7/14/31, incision and drainage of abscess of left thigh 7/17/31, transfusion 7/21/31, incision and drainage of right elbow 9/16/31, reamputation of right thigh, lower third, open 10/21/31, secondary suture of right stump, skin grafts 2/1/32, patient discharged
				<i>Diagnosis</i> Compound fracture right tibia and fibula, upper third, compound fracture tibia condyles, right, compound fracture left tibia and fibula, upper third, compound fracture of left patella, fracture left femur, lateral condyle, shock
				Amputation of lower third of right thigh for circulatory gangrene, amputation lower third of left tibia for anaerobic infection and circulatory impairment
11	22646	M	45 yrs	Adm 11/28/34 Truck ran over left leg Treatment of shock, debridement, open, Kirschner wire traction 11/29/34, pain and rising temperature 11/30/34, infection (anaerobic), perfringens serum, operation—disarticulation at left knee 12/11/34, incision and drainage 2/26/35, amputation of lower third of left thigh, open 3/29/35, patient discharged with small granulating wound 1/2/36, stump well healed and padded Wearing artificial leg four months
				<i>Diagnosis</i> Compound fracture left tibia and fibula, middle third, crushing injuries and avulsion of skin of left leg, fracture left fibula (lateral malleolus), shock
				Amputation left thigh, lower third, for anaerobic infection

There were five late deaths in this series (Table V) One (No 1) was not subjected to operation and, while both fractures showed a mild infection, the patient evidently died of hypostatic pneumonia, two weeks after injury One (No 4) died 13 days after injury which had been debrided and closed His chances would undoubtedly have been better without primary closure and amputation might have saved him One (No 6) is quite indefensible He was debrided and closed 23 hours after admission and died 12 hours after operation If any operative interference was necessary at that time, drainage alone was indicated

TABLE V

RÉSUMÉ OF LATE FATALITIES

Case No	Hosp No	Sex	Age	History, Diagnosis, Course and Cause of Death
1	29135	M	69 yrs	Adm 11/10/36 Struck by truck Treatment of shock, Russell traction to left leg and left arm, iodine, no closure Course was smooth until the twelfth day Died fifteenth day after admission <i>Diagnosis</i> Compound fracture left femur, middle third, compound fracture left humerus, lower third, fracture head of left fibula, fracture second, fourth and fifth metatarsals, right, fracture proximal phalanx of second toe, right, concussion of the brain <i>Autopsy</i> Bronchopneumonia, general and cerebral arteriosclerosis, cardiac hypertrophy, cardiac myocarditis, sclerosis of the coronary artery, sclerosis of the aorta, hypertension, chronic nephritis <i>Cause of Death</i> Bronchopneumonia
2	10580			(See Case No 3, Table IV Patient died 12 hours after amputation, six days after admission, from sepsis and shock)
3	7592	M	35 yrs	Adm 7/28/27 Elevator weight fell on right forearm Treatment of shock for nine hours Perfringens serum 7/28/27, operation—debridement and closure, repair of muscles and tendons, infection 8/4/27, transfusion Reaction followed by suppression of urine 8/10/27, operation—decapsulation of both kidneys Spinal anesthesia Died 15 days after admission, 8/12/27 <i>Diagnosis</i> Compound fracture neck and lower third of right radius, avulsion of skin of right forearm, division of muscles and tendons of right forearm, shock <i>Cause of Death</i> Kidney complication
4	8393	M	Adult	Adm 12/9/27 Automobile ran over left foot Treatment of shock 12/9/27, operation—debridement and closure, circular plaster encasement 12/13/27, infection (hemolytic Streptococcus), opened 12/14/27, blood culture showed hemolytic Streptococcus 12/18/27 and 12/19/27, incision and drainage, 12/20/27 and 12/22/27, transfusions Died 13 days after admission, 12/22/27 <i>Diagnosis</i> Compound fracture of lower third of left fibula, compound fracture tibia (malleolus), left, compound dislocation left foot <i>Cause of Death</i> Septicemia (hemolytic Streptococcus)
5	29213	M	60 yrs	Adm 11/28/36 Struck by automobile Treatment of shock 11/28/36, débridement, open Kirschner wire (6 pounds) Pneumonia Sepsis Wound clean Died 11 days after admission, 12/9/36 <i>Diagnosis</i> Compound fracture of right tibia and fibula, upper third, fractured pelvis, concussion of the brain, acute alcoholism <i>Autopsy</i> Bronchopneumonia, suppurative arthritis of the right sacro-iliac joint, internal hemorrhagic pachymeningitis, dislocation of the sixth cervical vertebra <i>Cause of Death</i> Pneumonia and sepsis
6	12466			(See Case No 8, Table II Death due to shock and sepsis)

Discussion—There is one point which stands out in our experience, and in that of others whose writings are sufficiently detailed to permit analysis, and that is the unfortunate results of primary closure following débridement. I feel that the inadequacy of debridement to accomplish its purpose, namely, sterilization of an infected compound fracture, has not been sufficiently emphasized or generally appreciated. Because it is the best method available to us, is no reason for shutting our eyes to its shortcomings. The type of crushing injuries in which it is most needful are the ones in which it is most futile. It must be agreed that primary closure has been resorted to too frequently in our cases, and the same statement has been made by Daland⁶ in his series, although he still employs it in selected cases.

In any compilation of a small series of compound fractures, mortality and amputation percentages are meaningless, since there are so many contributing factors. The statistics in this series are as follows. There were 26 deaths, or a total mortality of 20.3 per cent. If the 13 fatalities shown in Table I (mortalities within 36 hours) are excluded, the mortality in the remainder is 11.3 per cent. Sixteen patients were subjected to amputations, of whom one had amputations through both thighs. There were five amputations of upper extremities, three of the arm, and two of the forearm, with no deaths. There were 12 amputations of lower extremities in 11 patients, with two deaths. There were two amputations at the upper third of the leg, without mortality, and nine amputations at the thigh in eight patients, with one death. The other death followed shortly after an amputation through the knee joint. Of the 102 patients who survived, five were handicapped by the loss of an upper extremity, eight by the loss of a lower extremity, and one by the loss of both lower extremities. In other words, 13.7 per cent of the survivors were permanently handicapped by the loss of a limb. These are gruesome figures, but on analysis do not appear to offer likelihood of marked improvement, except by prevention.

At first glance, the infection rate in this series is much higher than in the series from the Massachusetts General Hospital, reported by Daland. If the statistics are compared with the instances of compound crushing wounds of the long bones, there is little discrepancy. Environment, age, type of patient, and type of injury will alter results and enter into the choice of treatment. Contamination of streets, the few children in this series, and the severity of the injuries militate against obtaining good results, and are representative of the business and waterfront districts of metropolitan ambulance services. There were nine anaerobic infections.

Since most of these cases must of necessity be relegated to the younger surgeon, it would appear better practice that most compound fractures should be left unsutured, and even the suture of tendons and nerves be postponed until wounds are healed and clean, except in the exceptional case. To provide adequate drainage, before infection has had time to infiltrate the tissues, should

be an essential part of any debridement in crushing injuries. The recent advances in plastic procedures permit healing of open wounds without increasing the period of disability beyond that of the fracture.

In many cases the use of preparations of sulfanilamide is a life-saving procedure. Its use as a prophylactic measure, or in suppurative infections other than hemolytic *Streptococcus*, is a question to be determined in the future. The value of gas gangrene antitoxin as a prophylactic agent is yet unproved, indeed, as a curative agent it leaves much to be desired.

CONCLUSIONS

In treating compound fractures, each of the following points needs emphasis:

- (1) Transportation in traction
- (2) The determination of complicating conditions must be made on admission
- (3) Shock must be combated before operative procedures are undertaken, by infusion, transfusion, *etc*
- (4) Debridement should be performed within six hours of the injury or not at all
- (5) Reduction and immobilization should be undertaken early
- (6) Late reductions, after infection is present, are contraindicated
- (7) The closure of wounds, with or without debridement, should be exceptional
- (8) Amputations are necessary for impaired circulation or spreading infection

REFERENCES

- ¹ Kennedy, R. H. Emergency of Extremity Fractures. *New England Jour Med*, 207, 393-395, 1932
- ² Kennedy, R. H. Transportation of the Injured. *Bull Amer Coll Surg*, 17, 1-10, June, 1933
- ³ Findlay, R. T. First Aid for Fractures. *Jour Bone and Joint Surg*, 13, 701-708, October, 1931
- ⁴ Orr, H. W. Principles Involved in Treatment in Compound Fractures. *Jour Lancet*, 54, 622-624, October, 1934
- ⁵ Pfeiffer, D. B., and Smyth, C. M., Jr. Treatment of Compound Fractures with Special Reference to the Orr Method. *ANNALS OF SURGERY*, 102, 1059-1068, December, 1935
- ⁶ Daland, E. M. Study of 236 Compound Fractures Treated at the Massachusetts General Hospital. *Northeast Jour Med*, 210, 983-995, May 10, 1934

DISCUSSION—DR. ROBERT H. KENNEDY (New York, N. Y.) brought up the point that the whole era of modern surgery was developed through surgery of compound fractures. In 1864, Joseph Lister, of Glasgow, was struck by the remarkable effects produced by carbolic acid upon the sewage in the town of Carlisle. He was so disturbed by the foul discharge and odor

coming from compound fractures that he decided to try carbolic acid on them. His chance came in March, 1865, in a compound fracture of the leg. The treatment was unsuccessful. However, in his report in the *Lancet*, in 1867, of the next 11 cases of compound fracture, one died and one had an amputation. Then followed the period of antiseptics and asepsis in surgery. Interest in improving the treatment of compound fractures really initiated the whole period of modern surgery.

The necessity of fixed traction transportation is generally ignored. It has been difficult to persuade surgeons that traction is necessary in simple fractures. It is equally as necessary in compound fractures, if not more so. All of these patients should be operated upon. Therefore, if a projecting fragment disappears within the wound, under traction, we should not feel that the danger of infection has been increased.

Debridement is absolutely necessary, but it is commonly poorly performed. Since the days of the World War no one has had a chance to perform them frequently enough. Within the last month one of Doctor Kennedy's interns told him that debridement meant to cut away the margin of the skin. He feared that some surgeons concurred in this as far as their actual procedure is concerned. Doctor Kennedy agreed with Doctor Heyl entirely on the necessity of performing debridement within six hours or not at all. However, strenuous efforts should be made to have the patient prepared within six hours. Doctor Kennedy said that he is strongly against closing the wound in a compound fracture, though this does not mean he never closes one. One has no right, however, he felt, to start with the idea that he is going to do so. Many factors must be considered before the surgeon has a right to take this responsibility. Whatever one does after the débridement and after reducing the fracture, he must obtain complete immobilization if a good result is desired. Incomplete immobilization certainly increases the chances of infection becoming established.

There has been some talk during the past two years regarding sulfanilamide in cases with gas infection. Doctor Kennedy said it is being used at Beekman Street Hospital. It is not known whether it affects the *Clostridium welchii* or only the *Streptococcus* that is frequently present, also, it may effect some symbiotic action between the two. It should be used both prophylactically and in treatment. But the use of sulfanilamide must not interfere with carrying out thorough surgical wound cleaning and subsequent drainage. Sulfanilamide is only an adjuvant to proper surgery.

DR FENWICK BEEKMAN (New York, N. Y.) said that the question of compound fractures had interested him for many years and that since the World War he had seen a great many different types of procedure developed, many of which were very advantageous, and others that had been taken up and thrown down. In the long run, the conservative surgeon has been the man who has done the most for the treatment of compound fractures. Doctor

Heyl has presented a very sensible and conservative surgical procedure to follow in compound fractures

Doctor Beekman concurred with Doctor Kennedy and Doctor Heyl that very few people *know* what débridement is. A patient with a blood pressure of 80 or below certainly could not stand the shock and hemorrhage of a débridement, and at the same time recover from the shock. In a débridement, one must have perfect anesthesia. A certain amount of hemorrhage is inevitable, unless one controls it with a tourniquet. Doctor Beekman personally could not see why one should increase the mortality, as, undoubtedly, would be the case if these patients were submitted in shock to immediate débridement. Undoubtedly the vast majority will recover from their shock with proper treatment long before six hours had passed.

Doctor Beekman also touched upon secondary attempts at reduction. Infection is certainly spread by attempts to get bones into alignment after a primary attempt has failed. Even within six hours, if further attempts at manipulation are made, one is going to get secondary hemorrhage and there will be a spread of any contamination that is present. Certain of the barriers that nature has put up in that short time are going to be broken down, and, under no circumstances, should any attempt ever be made at secondary reduction. One should get the best reduction possible at the beginning and then leave it alone.

Those who use the so-called Orr treatment have found it to be, in many cases, an ideal form of fixation. Traction is not as ideal because in traction any movement of the patient, as onto a bed pan, changing bed clothes, dressing wounds, or any other act, is bound to produce the same harmful effect as secondary attempts at reduction.

Doctor Beekman said that Doctor Heyl had been very brave, and he wished that more people would do what he has done, namely, present a case that has been a failure, in that case Doctor Heyl showed his mistakes, and, if more surgeons would do the same, a great deal could be learned.

DR JOHN M. HANFORD (New York, N. Y.) emphasized one factor of great importance, not only in the treatment of compound fractures but in all accidental wounds and in many operative wounds—something that is becoming more and more appreciated as worth while. It is the irrigation of these wounds—deliberate, prolonged, thorough irrigation with hot saline—no matter how small the wound may be, before, during and after the débridement. Some of these wounds are very small, nevertheless thorough irrigation may wash out bacteria and small particles. This simple factor of treatment should be carried out. He, himself, now irrigates many operative wounds, because the value of irrigation is generally accepted in accidental wounds and in compound fractures.

Another fact he emphasized was that even though the patient may be in

shock, irrigation can be carried on during that time. The wound may be very thoroughly washed out without adding to the patient's shock, especially if hot saline be used, even over a considerable period of time.

DR CLAY RAY MURRAY (New York) felt that Doctor Heyl had presented a valuable analysis of a series of particularly severe compound fractures. His stressing of the importance of the emergency treatment in compound fractures is not only extremely worth while but should be fully appreciated. Moreover, because a fracture is compounded, and the bone fragment is protruding, there has been a hesitancy on the part of many individuals to apply traction to the extremity because of the withdrawal of infected material into the tissues was something to be feared.

I should feel that if, in these cases, it were possible to perform a debridement and treat the wound within the time which one ordinarily feels that debridement may have its maximum effectiveness, there is every advantage in applying traction to these, just as much as to the simple fracture, because this debridement will drain adequately and open the wound within a brief period of time.

The first group of cases Dr Heyl outlined, those that obviously are going to die, it is certain that surgery upon the compound fracture is the height of optimism.

I do not believe that a patient suffering from shock—not resulting from complicating injuries—with a blood pressure of 80, 70, or even 60 Mm systolic on admission *must wait*. A delay of six or eight hours to pick up the patient's condition only to knock him down again with débridement, and at the same time lose the optimum benefit of the débridement by the delay. I do not believe this is either good surgery or good physiology. I see no reason why a patient with a compound fracture, not complicated by other injuries, suffering from shock, should not receive shock treatment coincidentally. If shock treatment is adequate—infusion, transfusion, cortine, etc.—there is no reason why the patient can not go to the operating room where his debridement is performed while shock treatment is being carried out. It is our experience that in cases in which the blood pressure was so low as to be almost unascertainable, if shock treatment is adequate and carried out coincidentally with debridement—without taking the patient out of his traction splint, without manipulation of the fracture, although little could be done for the fracture perhaps—debridement of the wound can be performed and is not a surgical mistake. It is a mistake to delay this particular type of case until they are recovering from their shock so that we can operate upon them later and knock them down again.

It is important at the time of operation to take cultures of the wound. Frequently, one may obtain culture reports within 24 to 36 hours which will anticipate evidences of wound infection, which may not become evident for four or five days.

I would like to subscribe heartily to the idea that no compound fracture wound should be closed. You may close them and get away with it, but I do not believe that the good fortune to get away with it, is justification for such a procedure. If they become infected they certainly do much more poorly than the wounds that are left open. The value of the surgeon's judgment whether such a wound should be closed was perfectly illustrated in the case Dr Heyl presented with lacerations not communicating with the fracture, and involving

only superficial tissues. If infection occurs, it is likely to involve the fracture. Wound tension is frequently the deciding factor between the development of septicemia or not.

There is just one other point, and that is the question of fixation of the compound fracture. That should be rigid, whatever method is employed.

ON THE CONTROL OF AIR-BORNE BACTERIA IN OPERATING ROOMS AND HOSPITAL WARDS

A PRELIMINARY REPORT

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PHYSICIANS have long believed that pathogenic bacteria are not carried by the air for more than a few feet from the patient's mouth. This opinion was badly shaken when W F and M W Wells¹ reported their work, four years ago. These Harvard investigators found that when broth cultures of almost any of the common pharyngeal organisms were projected into the air in the form of fine spray, the tiny droplets of fluid dried up and the bacteria, so to speak, perched on a tiny particle of solid material, remained alive, suspended in the air, for as long as two or three days.

Another important step in the field of air-borne infections was initiated by Deryl Hart,² who found that ultraviolet light would reduce the air-borne bacteria in the operating room. For this work, special mercury vapor lamps,* run on the same principle as neon tubes, were devised. They were made of Corex glass tubing which transmits ultraviolet light down to about 2,000 Å units, which is considerably shorter than the shortest ultraviolet in sunlight. It does, however, cut out the very short ultraviolet rays. About 80 per cent of the energy given off by this lamp is in the 2,537 band, which is definitely lethal to bacteria.

In 1936, the Hospital for Sick Children put in a new operating room equipped with air-conditioning, and a battery of eight of these ultraviolet lamps mounted around the central light (Fig 1). This set-up afforded a good opportunity to test out the efficacy of these two factors—air-changing and ultraviolet light—in removing bacteria from the air.

The air entering the room was forced in at a rate of about 370 cubic feet per minute, which created no draft but was sufficient to change all the air in the room once every eight minutes. The air was taken from the roof above the fifth story of the hospital and was cleaned by passing through sticky, corrugated paper filters. It contained about four bacteria per cubic foot when it entered the room, or, in other words, it was practically bacteria free. None of the air was recirculated. The temperature varied some 10° F (74°–84° F) and the relative humidity also showed great variation (30 to 75 per cent).

Submitted for publication December 12, 1938

* Westinghouse Sterilamps

The essential thing, so far as the removal of air bacteria is concerned, seemed to be the movement of air into and out of the room

To count the bacteria in the air the following simple apparatus was devised. A measured amount of air was slowly drawn (by means of a siphon arrangement) through a glass tube containing two tightly packed, sterile absorbent cotton plugs, one at either end of the tube. The ends of the tube were closed with rubber corks with holes through the center. After use, the second plug was dropped in a tube of broth and incubated. It was always

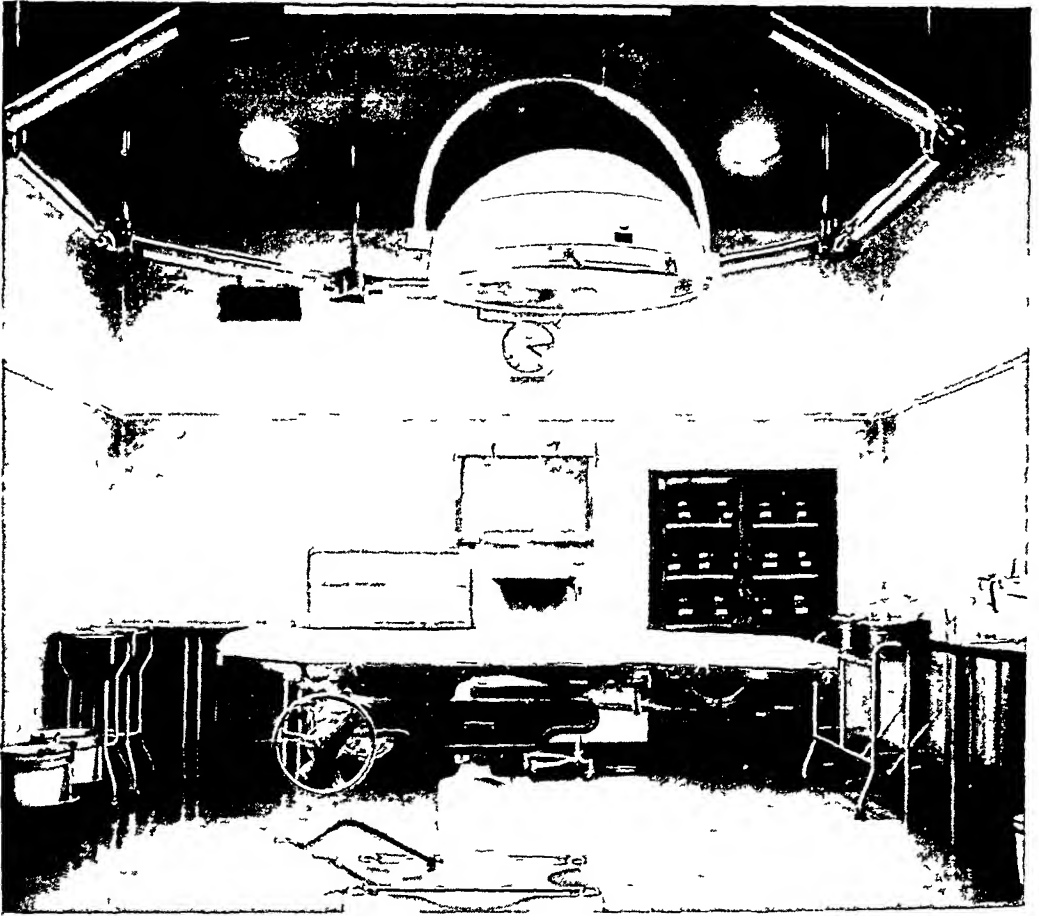


FIG. 1.—Operating room showing eight ultraviolet lamps suspended above the table. The air intake is on the upper left.

sterile, and, therefore, all the bacteria from the air passing through had been removed by the first plug. The bacteria then had to be washed out of the first plug and counted. This was done by mechanically shaking up the plug in 50 cc of sterile broth for 20 minutes. Although all the bacteria were not removed from the cotton plug by this procedure, the results in the various tests are comparable, as the method was constant throughout. After shaking, 10 cc of the plug-containing broth were added to 20 cc of cooled melted agar (2 per cent), one and one-half cubic centimeters of human blood were put in and the whole was poured into a large Petri dish. Three such plates were

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poured in each test to serve as checks After 72 hours incubation, the colonies of bacteria were counted and picked for identification

When making a count of the air bacteria in the operating room, the air was taken from as near the site of operation as possible* The flow of air through the plugs was started when the first incision was made, and was kept up until the last suture was placed, or until an hour's sample had been taken The air was drawn through at the rate of a little over a liter a minute Such

TABLE I
BACTERIA PER CUBIC FOOT OF AIR IN OPERATING ROOM
Operations lasting over 45 minutes

Air Off U-V Lamp Off	Air On U-V Lamp Off	Air Off U-V Lamp On	Air On U-V Lamp On
37	15	2	1
82	28	42	0
24	34	34	14
122	19	8	23
88	31	25	20
45	31	10	0
57	42	8	2
85	42	16	8
48	42	14	4
40	8		2
17	16		0
68	21		8
40	34		0
	28		1
	25		
	57		
	116		
	14		
	7		
	85		
	6		
	31		
	8		
	3		
	11		
	31		
	8		
	20		
	3		
	25		
	11		
	8		
	6		
	17		
Average 62	Average 26	Average 18	Average 6

* We are much indebted to Dr D E Robertson, Dr A W Farmer and Dr W S Keith for allowing us to take air samples in the operating room and for their kind co-operation throughout this work

counts were made during 70 different operations, lasting three-quarters of an hour or more, carried out under the various conditions of air-changing and ultraviolet light. The detailed results are shown in Table I.

On the average, when neither the air-changing nor the lamp was used, there were about 62 bacteria per cubic foot. When the air-changing only was used, there were less than one-half as many bacteria (26 per cubic foot). When the ultraviolet lamp only was used, there were less than one-third as many (18 per cubic foot). When both the air-changing and ultraviolet lamp were used, there were only about one-tenth as many bacteria (6 per cubic foot). Either the air-changing or the ultraviolet lamp was fairly effective in removing bacteria, although the lamp was the better of the two. The combination of both was very efficient, as the air then contained only slightly more organisms than the fresh filtered air that was being drawn into the room. The average number of bacteria per cubic foot of air in numerous operations lasting from 25 to 44 minutes, and from 15 to 24 minutes are shown in Table II. In general the results are similar to those shown in detail in Table I.

TABLE II
BACTERIA PER CUBIC FOOT OF AIR IN OPERATING ROOM
Operations lasting 25-44 minutes

	Aver No Bacteria Per Cubic Foot
32 operations with air off and U-V lamp off	74
42 operations with air on and U-V lamp off	33
12 operations with air off and U-V lamp on	25
18 operations with air on and U-V lamp on	14

Operations lasting 15-24 minutes

21 operations with air off and U-V lamp off	77
16 operations with air on and U-V lamp off	50
4 operations with air off and U-V lamp on	13
9 operations with air on and U-V lamp on	9

When the ultraviolet lamps were used, it was necessary for everyone in the operating room to wear glasses, a visor, and some protection over their necks, in order to avoid conjunctivitis and burning of the skin. Masks covering the nose and mouth were always worn in the operating room.

When the results obtained during different types of operations were compared, it was seen that there were more bacteria in the air during operations which necessitated considerable moving about by the operating team.

During operations, there were usually five or six people in the operating room, and the counts were as shown in Tables I and II. When the room was empty, or when only two people were in it, the counts were much lower. Therefore, the bacteria were largely due to the presence of people in the room. Counts made during the induction of the anesthetic and when the patient was being draped, were much higher than later, when the operation was proceeding.

quietly. No doubt many of the bacteria were stirred up from the floor, from the blankets, *etc.* As there were fewer bacteria out in the hall than in the operating room, the organisms were not entering through the hall door, which was opened many times during an operation.

The recently devised Wells' air centrifuge³ was also used for making bacterial counts. In this method the indrawn air is thrown against the inner surface of a cylindrical layer of moist agar that is being spun around. A sample can be taken in five minutes and read after 24 hours incubation. The method is certainly easy and rapid, but bacterial spreaders on the tubes sometimes make it impossible to count the bacteria. Also, this machine runs at such high speed that it causes considerable turbulence in the air. A five-minute sample was taken at about the middle of an operation and the counts obtained are shown in Table III. The Wells' centrifuge results agree in general with those obtained by our own method. They are lower because not all the bacteria are caught and because a clump of bacteria gives rise to only one colony by this method, instead of many, when the clump is broken up by the shaking used in our method.

TABLE III

BACTERIA PER CUBIC FOOT OF AIR IN OPERATING ROOM
(WELLS' AIR CENTRIFUGE METHOD)

Operations lasting over 45 minutes

Air Off	Air On	Air Off	Air On
U-V Lamp Off	U-V Lamp Off	U-V Lamp On	U-V Lamp On
13	6	9	6
16	6		4
15	5		2
29	8		
18	3		
6	11		
7	4		
	12		

In addition, we always set out blood agar plates during the operations, but this method is of little value when the ultraviolet light is used, as the light will kill bacteria after they fall on the plate if they are exposed to its rays for five minutes. So the only bacteria that grow on these irradiated plates are those that have fallen on them during the last five minutes of exposure. The number of colonies on blood agar plates, set out for one hour, during operations carried out under the four conditions tested, are shown in Table IV.

The types of organisms found were as follows. About 50 per cent were large gram-positive Cocci in tetrads—a common, probably harmless type of air bacteria. About 25 per cent were Staphylococci, mostly *albus*, although *aureus* strains were found fairly often. The other 25 per cent were made up of diphtheroids, aerobic spore bearers, and thin gram-negative Bacilli.

In seven operations, the throats of all the staff present in the operating room were cultured. Of these, 20 showed *Streptococcus viridans* and eight,

Streptococcus hemolyticus However, neither in these nor in any of the other operations did we obtain Streptococci from the air by our method or by that of Wells In one operation, in which no throat cultures were made, a few hemolytic Streptococci were found on one of the blood plates that had been set out

TABLE IV
NUMBER OF COLONIES OF BACTERIA, PER PLATE, GROWING ON
BLOOD AGAR MEDIA

<i>Operations lasting 60 minutes</i>			
Air Off	Air On	Air Off	Air On
U-V Lamp Off	U-V Lamp Off	U-V Lamp On	U-V Lamp On
52	26	5	1

The large, air-borne Cocci are relatively hard to kill with heat and are probably generally resistant to lethal agencies However, this ultraviolet light kills them If it can kill the resistant organisms, it would probably kill off the less resistant pathogenic organisms more readily

The surgical staff did not observe any change in the rate of healing of the wounds in the children operated upon under the lamp The cases were practically all "clean" cases, and were for the most part brain operations, plastic skin operations, sympathectomies, bone operations, appendicectomies and hermiotomies Such wounds heal very rapidly in children anyway, and it would be difficult to demonstrate an improvement in healing as the result of exposure to the lamp Only one of the irradiated cases showed postoperative infection in the wound This child was operated upon for contracture of a finger following an injury six months previously The original wound had been infected with Staphylococci The tendon was lengthened, surrounded with cellophane and covered with skin and subcutaneous tissue The infection, therefore, might have been a lighting up of an old focus

The degree of postoperative temperature of the children operated upon under the ultraviolet light was not appreciably lower than that of the controls In a great many cases they were given injections of antitoxin shortly after operation which made it difficult to interpret their temperature reactions Deryl Hart² found that adult patients operated upon under the ultraviolet lamps showed lower temperatures and more rapid wound healing than the controls

Air bacteria counts* were also made in a crowded hall in the Out-Patient Department, from a large ward in which there were 14 to 17 older children, and from infant ward cubicles containing three to six babies As is shown in Table V, the number of organisms was very large in the first two locations In the large ward, the counts were made while the ward was being swept, or shortly afterward They varied to some extent with the vigorousness of the sweeping

* Using the author's method

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TABLE V

BACTERIA PER CUBIC FOOT OF AIR, FROM PARTS OF
THE HOSPITAL OTHER THAN THE OPERATING ROOM

Medical O P D	Large Ward	Cubicles on Infant Ward
538	113	85
424	226	57
212	991	14
368	963	57
424	85	85
706	113	14
651	623	170
566	312	57
368	113	19
85	57	57
283		
304		

An investigation is in progress on the infant ward to find out if a combination of air-changing and ultraviolet light will diminish the incidence of secondary infections

SUMMARY AND CONCLUSIONS

Counts of air-borne bacteria were made in an operating room equipped with air-conditioning (eight changes an hour) and special ultraviolet lamps (Westinghouse Sterilamps). With neither air-conditioning nor lamps the average number of bacteria per cubic foot of air was 62. By the use of air-conditioning this was reduced to 26, when the lamps alone were used the count fell to 16. When both air-conditioning and ultraviolet lamps were used, only six bacteria per cubic foot were present. About half of the bacteria were harmless air-borne Cocci.

Either air-conditioning or ultraviolet lamps markedly reduce the air-borne bacteria. Of the two, the latter is more effective. The combination of both these agents is very efficacious.

Counts made in cubicles on the infant ward averaged 61 bacteria per cubic foot. Those made on a large children's ward or in the Out-Patient Department were much higher.

With a combination of air-conditioning and ultraviolet lamps it should be possible to reduce air-borne secondary infections in the wards.

REFERENCES

- ¹ Wells, W. F. On Air-Borne Infections. *Am Jour Hyg*, 20, 611, 1934, and *J A M A*, 107, 1698 and 1805, 1936.
- ² Hart, D. Sterilization of the Air in the Operating Room by Special Bactericidal Radiant Energy. *Jour Thorac Surg*, 6, 45, 1936, and *Arch Surg*, 34, 874, 1937.
- ³ Wells, W. F. Apparatus for Study of the Bacterial Behaviour of Air. *Am Jour Pub Health*, 23, 58, 1933, and 27, 97, 1937.

BRIEF COMMUNICATIONS AND CASE REPORTS

THE ELIMINATION OF RUBBER TUBING ON INTRAVENOUS SETS

A NEW SYSTEM FOR THE ADMINISTRATION OF INTRAVENOUS SOLUTIONS

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DETROIT, MICH

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THE USE of rubber tubing in the administration of intravenous therapy goes back as far as we can trace this type of treatment and is, at the present time, conceded to be a necessity along with the container, needles, clamp, and tourniquet, unless the amounts of fluid to be given are small enough to be administered with a syringe

The care of rubber tubing used in intravenous work is indicated in the quotations from Little¹ and Walter² as follows

Little¹ "Rubber tubing must be prepared initially by boiling in a 4 per cent solution of sodium hydroxide, cleaning with a brush, preferably a wire brush, and rinsing in fresh distilled water. Brushing and rinsing should be repeated after each using. This is necessary because new rubber tubing has a surface coat of talc both inside and out which must be removed. Old rubber tubing requires the same cleansing on account of the sulphur which is present in the rubber and which gradually sublimates out. Within the past few years a new type of rubber tubing has become available—acid-cure tubing. In this kind of tubing no sulphur has been used and the care of such tubing is greatly simplified. It long has been known that the powder on new tubing must be removed. It is less generally recognized that sulphur gradually sublimates out of rubber and coats the inner surface with finely divided, easily dislodged particles. Clamping and pinching the tube loosens these and such handling of improperly cared for tubing frequently is followed by a chill."

Walter² "The 'bloom' is removed from new rubber by treating it with 5 per cent sodium carbonate solution in an autoclave at 250° F, for 30 minutes. The rubber is then rinsed with 1 per cent hydrochloric acid followed by distilled water. Care must be taken that the inside of the tubing is full of solution, otherwise the inner surface, which comes in contact with the parenteral fluid, will not be properly cleaned. The tubing is coupled together with glass connectors and boiled for 45 minutes in a 0.5 per cent solution of sodium hydroxide. The alkali, from a convenient reservoir, is run through the tubing continually during the boiling. After the tubing is cool, distilled water is run through it for 30 minutes."

Not only is rubber tubing difficult and time-consuming to prepare, but the first cost of good tubing is from five to ten cents per foot, and repeated preparation and sterilization soon causes the inner surfaces to become sticky. At the same time the rubber loses its "life" and must be frequently replaced on this account.

In seeking a method of eliminating rubber tubing it seemed highly desirable to avoid, at the same time, re-preparation and re-sterilization, if possible. In other words, the ideal material to replace rubber tubing would be one which contains no proteins, sulphur, or other undesirable substances and yet one which is cheap enough to be used once and discarded.

Such a material was found in seamless cellophane tubing. Tests, by Dr. O. H. Gaebler, show that the tubing contains no protein or sulphur. The surfaces are thinly coated with glycerine but this is removed in the preliminary washing with distilled water. Biologic tests on rabbits, using saline and glucose solutions kept in contact with this cellophane for 24 hours and sterilized in contact with it, showed no elevation of temperature or other reaction during three hours' observation.

In order to make the use of the cellophane tubing economical, it was necessary to work out a connection at each end which could be made quickly, was strong and safe, yet did not cut or puncture the tubing. The simple procedure of inserting a one-inch length of tubing within the bore of the cellophane tubing and then doubling the ends of both back as shown in H-3, was finally evolved. This connection is durable and flexible so that it forms a tight seal at the cork and about the shank of a needle G or syringe F. The cost of each cellophane tube unit is about two cents.

The use of glass tubing is avoided by running the cellophane tubing directly through the cap H. Air is filtered through the felt washer H-1, and replaces the fluid as the latter flows into the patient's vein. Sandblast graduation of the bottles and hanger C, made from vacuum caps and stainless steel, allow the use of standard, electrically annealed pharmacy bottles.

For actual use the solutions are bottled and sterilized as usual. The cellophane tubing with rubber tip connections, the bakelite cap and the felt washer are put up in a small glass jar A or other container. These may also be put up in bakelite containers which screw on as the original bottle top. The latter arrangement would perhaps be more convenient in case of packaging and shipping but when made and used locally the glass jar is preferred.

The actual steps in using the new apparatus are as follows. The cellophane tubing E, $\frac{3}{8}$ -inch diameter, is washed through in 96 feet lengths with distilled water. It is then divided into six-foot lengths and the bakelite cap H-2 is slipped over it. The rubber tips H-3 and G-3 are now inserted. The tube with cap and tips is placed in glass jar A with felt washer H-1. A few drops of water are added and the jar is sealed tightly with the aluminum cap A-1. The set is now sterilized with steam at 20 lbs., for 30 minutes.

In administering the fluid the cap is removed from the bottle and from the small jar. The washer H-1 is removed from the jar with sterile forceps and

placed over the neck of the bottle. The jar is turned upside down over the bottle and the bakelite cap allowed to settle over the neck of the bottle and screwed down snugly over the washer. The needle G-1 of the syringe F is

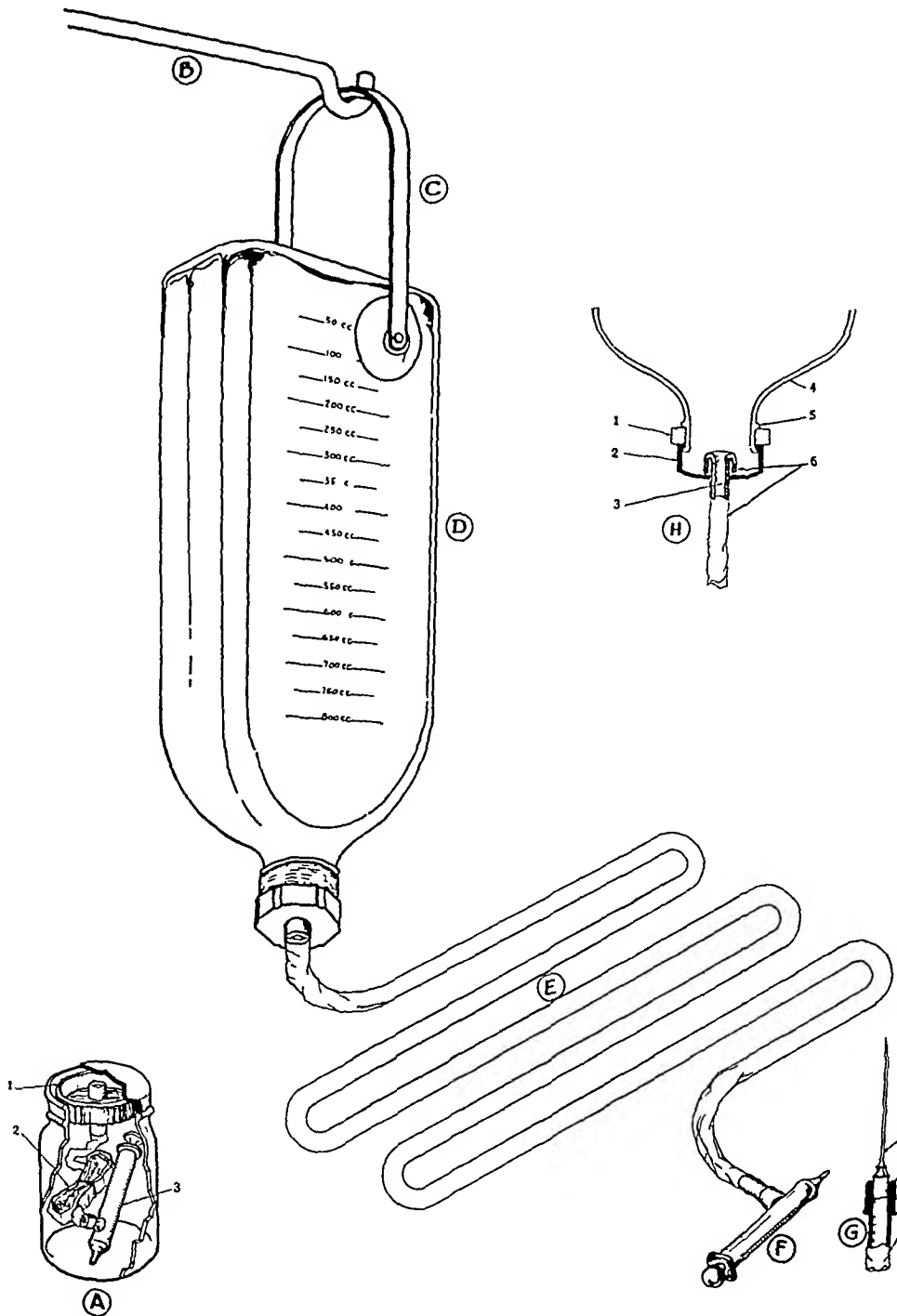


FIG 1.—Diagrammatic sketches of assembled apparatus

attached to the free end of the cellophane tube. The hanger C is placed on the bottle and hung on the support B. The tube fills slowly because it is collapsed

ADMINISTRATION OF AVERTIN

and may have to be "milked" just below the bottle with thumb and finger. Once filled, the bubbles are simply allowed to gravitate back to the bottle. Forcing the bubbles back may saturate the felt washer and interfere with air filtering through into the bottle.

SUMMARY

A new system of administering intravenous solutions with the elimination of rubber tubing is described which is more economical than previously described methods because of its simplicity, low first cost and low maintenance costs. It provides a fresh new tube for each administration which is chemically clean and free of all substances which might produce reactions.

It provides full visibility as to the character of the solution, bubbles and blood from the patient.

REFERENCES

- ¹ Little, W. D. Causes for "Reaction with Chill" Following Intravenous Administration of Normal Salt Solution. *Jour Ind State Med Assoc*, 25, 344-345, 1932.
- ² Walter, Carl W. Preparation of Safe Intravenous Solutions. *Surg, Gynec, and Obstet*, 63, 643-646, 1936.

A NEW CATHETER FOR ADMINISTRATION OF AVERTIN ANESTHESIA TO INFANTS AND CHILDREN

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AND

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THERE is some difference of opinion as to the advisability of using basal avertin anesthesia in very young patients. In the experience of the Surgical Service in the Children's Hospital, Boston, where it has now been used in over 7,000 cases, it has proved eminently satisfactory. In the neurosurgical cases with which we have been entirely concerned, avertin has been particularly valuable, since we have relatively few patients old enough to make local anesthesia feasible. The majority of these patients must have general anesthesia through a period of from one to four hours and they undoubtedly have less severe reactions to operation with good basal anesthesia and a correspondingly smaller amount of ether. Occasionally it is possible to carry out the greater portion of a major neurosurgical procedure with avertin alone.

It has been our custom to give a 100 mg. per kilo dose, which gives the desired result when the solution is retained until absorption is complete.

Submitted for publication August 18, 1939

Frequently it is impossible for young children to retain the solution even when they are cooperative. Obviously, in the very young patients, there is likelihood that the avertin will be at least partially expelled.

The catheter pictured* (Fig. 1 A and B) has been devised to obviate this difficulty, which it has done completely. The catheter is inserted so that the potential bulb lies just inside the internal sphincter. The bulb is then distended with 6 to 10 cc. of water, depending upon the size of the patient. The avertin is run in through the larger channel and cannot be expelled until the bulb is deflated. Ordinary wooden golf tees make very efficient stoppers

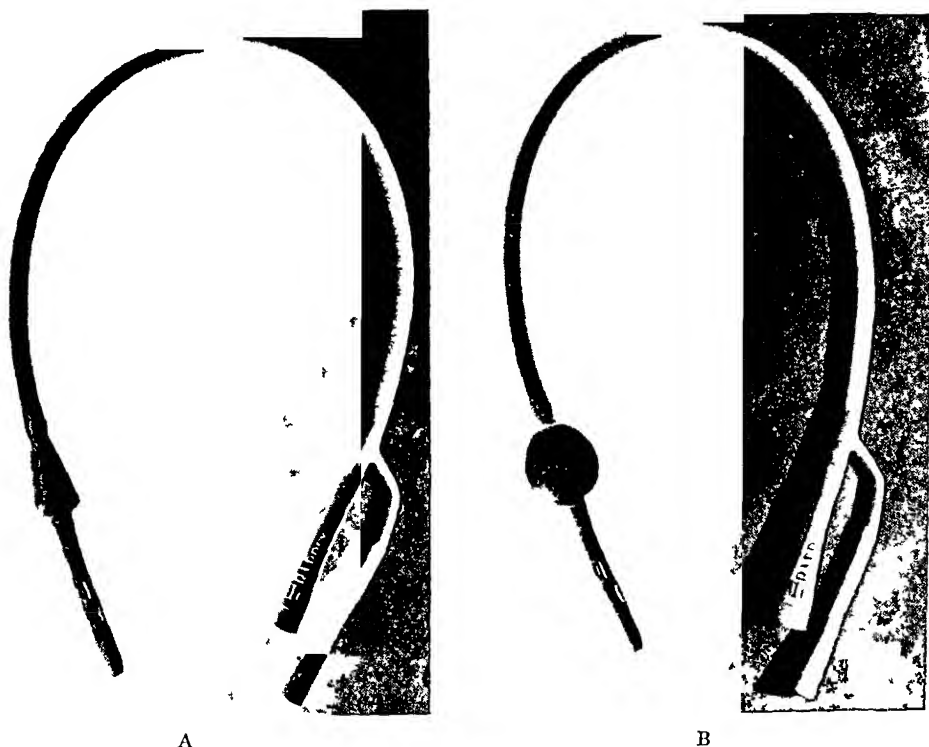


FIG. 1.—Shows the catheter before (A) and after (B) distention of the bulb.

for the open ends of the catheter and are less damaging than the use of a clamp. A nongreasy lubricant must be used.

This instrument has proven very useful, and is described so that it may be helpful to others interested in the administration of rectal anesthesia to very young patients, or to older patients who, for one reason or another, are uncooperative.

* Manufactured by the Davol Rubber Co. and distributed by C. R. Bard, Inc.

IN MEMORIAM

WILLIAM J MAYO

1861-1939

AND

CHARLES H MAYO

1865-1939

NO ASSEMBLY of doctors should permit an opportunity to pass to pay homage to the lives and works of Drs W J and C H Mayo—herculean in their achievements and yet withal so simple and direct in their manner. The world-renowned Mayo brothers died within two months of each other (May 26, 1939 and July 28, 1939) as though the one left could not endure to live alone, and this was characteristic of their lives. The younger died first as the elder would have preferred it, with his matchless love for his brother.

Men admire those who can do superbly what ordinary man can do well. There was no showmanship about their surgery—only directness and perfection.

"Doctor Will," as he was affectionately called, specialized in the surgery of the abdomen. "Doctor Charlie," equally beloved, did everything well, not only in the abdomen, but in the eye, the brain, and all of the deformities of the body and its diseases. Which was the greater surgeon? Once asked that question in Boston, I replied, "Doctor Will is a wonderful surgeon. Doctor Charlie is a surgical wonder." And so they strove, first helping each other and then thinking of the training of others.

John B. Murphy first told me about them in a spirit of great enthusiasm. He had never seen anything like it. He marveled at their surgical ability. He wondered at their enormous amount of work and commented upon their surprising results, and the thing that struck him most was that they had the same pocketbook. That seemed incredible. Yet I came to learn that it was perfectly true.

Thirty-eight years ago I went to the small town of Rochester, Minn., to see these wondrous men. I have watched the development of the greatest institution in the world by many pilgrimages, and the passing of a mere village into a Mecca for surgeons, and have observed the throngs of people who came for the beneficent services of their large group who work together so effectively—over 300 (1,000 new patients registered on one Monday last summer).

What has made them so great? Simplicity, industry, and honesty. No two men ever worked more diligently and more joyously. They were the surgical travelers of the world. No clinic of any renown but had seen their

* Read before the Society of Clinical Surgery, November 10, 1939, Boston, Mass.

oft-repeated visits. They garnered together every new and useful technic, every modern and usable idea.

Honesty of the most meticulous type was their watchword. Once, Doctor Will had devised and practiced an operation for resection of the stomach—the Pólya operation. It had all been illustrated, perfected, and was ready for publication. He learned that it had been published in an obscure Hun-

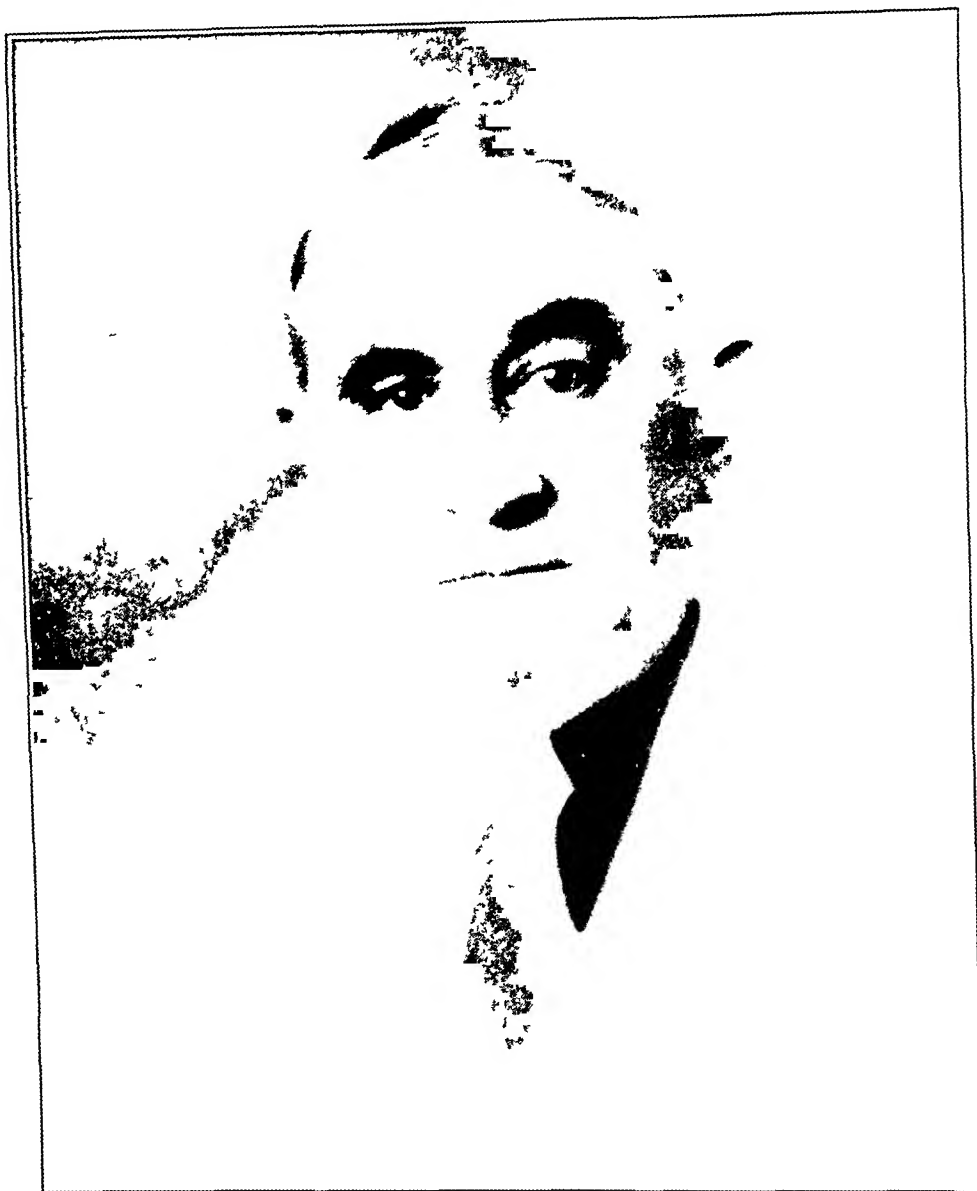


WILLIAM J. MAYO, M.D.

garian journal. The author had only employed it but a few times, and it had been lost. Doctor Will at once gave it the rightful name, practiced it, popularized it, and made it the operation of choice throughout the world. Their honesty was not of the compromising type. It was absolute. To that, I ascribe their tremendous achievements. Their rare unselfishness, not wishing to take the whole spotlight, always willing to share it with others—the constant addition of new names of clinicians, surgeons, bacteriologists, chemists, physicists, and biologists. They knew what it took to make a great

clinic They upheld the pure scientist, and put him on the same basis as the clinician They are indispensable one to the other

Almost every country in the civilized world honored these men with membership in their societies, honorary degrees in their universities, medals and decorations from their governments, Fellowships in the Colleges of the world and citations from the nations The mere list is too long for



CHARLES H. MAYO, M.D.

repetition Their diplomas filled a large room The only other thing it contained was a little emblazoned line—THERE IS NO FUN LIKE WORK

In 1915, they created the Mayo Foundation for Medical Education and Research through funds given outright to the University of Minnesota together with the clinical and laboratory facilities and personnel for carrying on graduate medical education and research Thereby the Mayo Foundation became a part of the Graduate School of the University of Minnesota

In a letter to the University of Minnesota transferring these funds

and making possible this arrangement, one of them wrote "Our father recognized certain definite social obligations. He believed that any man who had better opportunities than others, greater strength of mind, body, or character owed something to those who had not been so provided. That is, the important thing in life is not to accomplish for one's self alone, but each should carry his share of collective responsibility. The fund which we had built up and which had grown far beyond our expectations had come from the sick and we believe it ought to return to the sick in the form of advanced medical education which would develop better trained physicians and research to reduce the amount of sickness. The people's money, of which we have been the moral custodian, is being irrevocably returned to the people from whom it came."

Then simplicity and kindness were their greatest assets. I saw one of them walk around an ant hill and its two rows of workers that he might not molest them industriously, the other, escort a dear old lady across the street from the clinic, about which she was inquiring, never telling her that he was the great physician to whom she had come.

The one thing that they had that I have never seen equalled was their great love one for the other—not ostentatious, but very real. Whoever heard of one brother who would not have money, honor, or fame that he could not share with his brother? Neither of them could have builded that greatest of all clinics. It took their joint efforts.

Loyalty to their friends was unsurpassed. To each of themselves and to each other they were true.

*"To thine own self be true,
And it must follow, as the night the day,
Thou canst not then be false to any man"*

They were the surgeon's surgeon. I think we counted on one occasion almost a dozen members of the American Surgical Society upon whom, or their wives, they had operated.

The growth and development of the monumental Mayo Clinic has been so tremendous. No man of whatever great reputation was too big for them to take in. Their development of younger men was nothing less than phenomenal. The medical man who has not been there to partake of its great lessons has neglected a part of his education. They had written prodigiously—over 500 papers, addresses, *etc.*, each. Their "Collected Papers" is the surgeon's Bible. The incisiveness of their lectures while operating is treasured.

The home lives of these men have been so precious. Nobody ever had more devoted wives whose loyalty and affection so stimulated and supported them. Their devoted mother agreed to a mortgage on the farm for their first microscope and their famed father gave them unswerving character, high ideals, and their unforgettable early training.

For years they had no other god than surgery. The amazing dexterity

of the elder in operations upon the stomach, the gallbladder, the pelvis, the colon and rectum, the kidneys and ureters was unsurpassable. The genius of the younger brother was shown not only in abdominal surgery but in the development of the operations upon goiter, the prostate, the glands of the neck, staphylorrhaphy, the female breast, and in the beginning of his work he did all of the surgery of the eye and with very great deftness. After a grilling day's work they always took a nap after luncheon, which added greatly to their health. They practiced early rising and abstemiousness.

Will Mayo was a great master at surgery. Charlie Mayo was most gifted in getting out of the hard places in surgery. Then he rose to his full height.

In the passing of Doctor Charlie, all the world paused in reverence for his great surgical genius and to give him the encomiums of his wonderful career—laurel for honor and rosemary for remembrance. His elder brother, who followed him to the Great Hereafter, was a faithful physician, an inspired organizer, a superb surgeon, a great dreamer who saw his dream come true, kindly and sympathetic, and a true humanitarian—a man who has left a magnificent statue of himself on the minds of all true physicians. He had as his motto "He loved the truth and sought to know it."

As the world moves on, it pauses to do them honor and to pray that their equals may be seen again. As long as life endures, the magic name of "Mayo" will glorify medicine. Were I to attempt to dedicate a few words to their memories it would be

SURGEONS, SAGES, SCIENTISTS
MAKERS OF SURGEONS
MEDICAL PHILOSOPHERS
FOUNDERS OF GROUP MEDICINE
BENEFACTORS OF MANKIND

WILLIAM D. HAGGARD

JOHN DOUGLAS

1875-1938

DR JOHN DOUGLAS was born in New York City in 1875 and died December 5, 1938



JOHN DOUGLAS M D

Doctor Douglas was graduated from the College of the City of New York, and from the College of Physicians and Surgeons, Columbia University. He completed his internship at St. Luke's Hospital in 1900. In 1903, he was ap-

pointed Assistant Surgeon, in 1916, Associate Attending Surgeon, and in 1927, Attending Surgeon. In the latter capacity he served until his death.

From 1903 to 1938, he was associated with Bellevue Hospital as Adjunct Assistant Surgeon, Assistant Visiting Surgeon, Visiting Surgeon, and Consultant in Surgery. He was Professor of Clinical Surgery at New York University Medical College. From 1920 to 1927, he was Surgical Director of the Knickerbocker Hospital, and from 1927 to 1938, the Consultant Surgeon.

Doctor Douglas was deeply interested in organized medicine, and made many personal sacrifices for the cause. He was President of both the County Medical and the New York Surgical Societies. In these offices he won the respect and admiration of all who came in contact with him.

Doctor Douglas was a member of the New York Academy of Medicine, the American Medical Association, Fellow of the American College of Surgeons, the American Surgical Association and the International Surgical Society (Brussels).

Doctor Douglas was a skilled surgeon of sound judgment and great ability. His cheerfulness, kindness and innate sense of humor endeared him to all his patients.

The brief review of the many positions of trust so ably administered by Doctor Douglas can at best only indicate his professional and organizing abilities. Those who were in his confidence knew what a brave heart he bore. No soldier of the line did his duty more steadfastly or more cheerfully than Doctor Douglas. He was a man among men.

Doctor Douglas was very anxious to go to war, and it was one of his greatest regrets that circumstances beyond his control would not permit it. His colleagues, on their return from the service, found checks awaiting them for the services he had rendered their patients, and nothing could be done to change his unselfish attitude. Doctor Douglas was one of the finest characters we had on our staff. It can be said of him that he courageously faced and overcame some of the greatest personal sorrows that a man could have. A smile, a good story, a cheerful word, and an act of kindness were his answer. He was human, lovable and a steadfast friend.

When we are called to cross the bar and put out to sea, may we bear with us such a shining record of love and duty done.

HENRY H. M. LYLE

BOOK REVIEWS

FRACTURES By PAUL B MAGNUSON, M D, F A C S, Associate Professor of Surgery, Northwestern University Medical School, Third Edition, 511 pages, with 317 illustrations Philadelphia, J B Lippincott Co, 1939

THE AUTHOR has succeeded admirably in condensing the fundamental considerations of the treatment of fractures into a 500-page volume. The book is essentially a textbook and is of particular value to the medical student and the physician who occasionally treats a fracture. The theme of the book is well illustrated by the following aphorisms which the author tabulates on the first page

"Splint 'em where they lie

Shock is caused by fracture and is made worse by handling

Treat the shock, stop the hemorrhage, splint the fracture, and transport the patient to a hospital

Treat the wound, and reduce the fracture after recovery from shock

Study the muscles and then pull

Bring the fragment which can be controlled into alignment and rotation with the fragment which cannot be controlled

Check frequently with X-ray

Watch fixation apparatus constantly

Allow no painful points of pressure under any splints or casts

A fracture properly reduced and held in reduction is painless"

The material is well organized. The first four chapters are devoted to the fundamentals, general principles of fracture treatment, pathology and repair of fractures, and the anatomic mechanisms and physical equipment in the reduction of fractures. The remainder of the book is devoted to the treatment of specific fractures. The mechanics of injury are analyzed in relationship to the anatomic peculiarities of each fracture. The muscle forces involved in the production and maintenance of the deformity are described and the best method of overcoming these forces explained.

Closed methods of treatment are stressed but the more common open operative technics are also described. The author prefers to use splints and traction instead of the almost universally used plaster of paris encasements following the reduction of fractures. "All the methods described in this book have been thoroughly tried in practice. There are many more which are as good, there may be some that are better, but these have worked! And with thought and attention to detail they will work in the hands of any man, because they are simple and because they all take into consideration the anatomy and physiology of the parts under treatment, with the mechanical features simplified so that they may be applied without any great amount of special equipment. If the direction and amount of force which causes the fracture, plus the muscle pull which maintains the fracture deformity, is clearly understood before treatment is undertaken, with certain fundamentals in the mechanics of reduction provided for in the way of physical equipment, the surgeon's ingenuity can be relied upon to meet the requirements of the individual case."

ROBERT L. PRESTON

BOOK REVIEWS

THE SURGERY OF INJURY AND PLASTIC REPAIR By Samuel Fomon, Ph D, M D 1,418 pages 2,000 illustrations, many in color A William Wood book Baltimore, Williams and Wilkins Co, 1939

Dr Samuel Fomon's *The Surgery of Injury and Plastic Repair* is a fortunate addition to the ever growing and voluminous literature on plastic surgery. The work represents the compilation of a vast selection of publications and periodicals by leading authorities and includes translations which, until the present time were inaccessible in one volume. The author has selected the newest and most standardized surgical methods. The complete story of the surgical steps in these chosen operations is very clearly and accurately illustrated by numerous detailed drawings. In describing the operative procedures he attains a fluent and easy style and carries through the principles of physiologic rehabilitation and anatomic restoration, beyond mere cosmetic repair. The author minimizes historic background and the usual superfluous "before and after" pictures which are unimportant from the teaching standpoint, and concentrates on modern surgery.

The book comprises 22 chapters, covering complete regional surgery of the external head with the greatest emphasis placed upon the surgery of the nose. There are chapters describing operations in general, tissue transplantation, in which chapters are described and excellently illustrated, from the destructive to constructive stages, common types of skin transplant employed at present, chapters on wounds, burns, fluid, salt and acid-base balance, shock, anesthesia, preoperative management of the surgical patient, post-operative management, the cranium, the eyelid, the auricle, the maxillofacial region, the lip, cleft lip and cleft palate, the mandible, the salivary glands, surgical affections of the skin, and a chapter on plaster encasements and prosthesis.

The chapter on the nose is most featured. It describes various nasal operations which are clearly explained and illustrated in detail by excellent drawings, from the preoperative measurements of the ideal nose to the correction of every common type of congenital or acquired nasal deformity. The chapter includes diseases of the nose, and follows through with the post-operative treatment.

The bibliographies at the end of each chapter and the index are exhaustive, practical and complete. To the specialist, the general practitioner or the postgraduate student, the book is an excellent reference because the entire range of plastic surgery of the head has been covered.

MORTON I. BERSON

TUMORS OF THE SKIN—BENIGN AND MALIGNANT By Joseph Jordan Eller, M D Octavo, 607 pages Illustrated Philadelphia Lea & Febiger, 1939

THIS BOOK by Dr Joseph Jordan Eller will be of the greatest use to the practicing surgeon. Apart from the manifold advantages of finding in one volume a comprehensive and profusely illustrated text, his succinct and very intelligible modes and methods of treatment are so clearly expressed that the book can be easily understood by every practitioner of medicine.

The book shows the greatest care both in presentation and its admirable clarity and also in the extensive research which must have been entailed. The chapter on Plastic Surgery is of especial interest to the general surgeon, and it is a refreshing experience to find in one volume such a wealth of

information. Especially do I like his arrangement of the various types of tumor, from the simple keloid to the malignant growth, and the very clear way in which he has classified the types and the different methods of treatment advocated by the most authoritative specialists of the world. To find in one comprehensive volume such a wealth of information is a boon to the doctor who, of necessity, has to spend so much time in research.

The illustrations are excellently executed, and the photographic reproductions clear. The bibliography is profuse and encourages research. This book should be in the library of not only the dermatologist, but of every practitioner of medicine and surgery.

BERTRAM C. ESKELL

EDITORIAL ADDRESS

Original typed manuscripts and illustrations submitted to this Journal should be forwarded prepaid, at the author's risk, to the Chairman of the Editorial Board of the ANNALS OF SURGERY

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1833 Pine Street, Philadelphia, Pa.

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Exchanges and Books for Review should be sent to James T. Pilcher, M.D., Managing Editor, 121 Gates Avenue, Brooklyn, N.Y.

Subscriptions, advertising and all business communications should be addressed

ANNALS OF SURGERY
227 South Sixth Street, Philadelphia, Pa.



PATHOLOGIC CLASSIFICATION, WITH SURGICAL CONSIDERATION, OF INTRASPINAL TUMORS^{*}

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JAMES W KERNOHAN, M D

SECTION ON PATHOLOGIC ANATOMY

AND

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THE MAYO CLINIC, ROCHESTER, MINN

A REVIEW of a large series of intraspinal lesions for which operations were performed at the Mayo Clinic reveals a preponderance of benign tumors which were operable. The earlier intraspinal tumors are recognized, the less will be the damaging effects on the spinal cord and the more complete will be the recovery of the patient when the pressure has been relieved by the removal of the tumor.

The factors responsible for the development of tumors of the meninges, nerve roots, blood vessels and the spinal cord are similar to those responsible for the development of tumors elsewhere. They occur most frequently in the third, fourth and fifth decades of life, but may occur among children or among elderly patients.²⁴ Trauma may be a predisposing factor to the development of osteomata, sarcomata, foreign body giant cell tumors and fibromata. Trauma is also responsible for the rupture of the intervertebral disks with protrusion of the nucleus pulposus into the spinal canal. Although the lesion under consideration may produce symptoms similar to those of caudal tumors, it is not a true neoplasm. Trauma and chronic infection may give rise to hypertrophic arthritis and osteitis, both of which are capable of producing radiculitis and slowly progressive myelitis simulating the symptoms of intraspinal tumor. Primary malignant tumors of the osseous system, as well as metastatic lesions, are rarely considered surgical lesions, although a number of patients having such tumors have been surgically explored when it was not possible to make a preoperative differential diagnosis. Hemangiomata of the vertebrae, Paget's disease of the spinal column and Potts' disease of the vertebrae frequently produce involvement of the nerve roots and spinal cord, but are rarely benefited by surgical intervention.

Symptoms—Tumors which arise from the tissues surrounding the spinal cord have been designated as "extramedullary," in contrast to those which arise in the cord itself, which have been called "intramedullary." Oppenheim

^{*}Read before the meeting of the International Cancer Congress, Atlantic City New Jersey, September 14, 1939. Submitted for publication October 16, 1939.

and Frazier have divided the symptoms of extramedullary tumors into three phases. The first phase is that of involvement of nerve roots,³¹ the second, that of beginning compression of the spinal cord, and the third, that of extreme compression of the spinal cord, producing the clinical picture of transverse section of the cord.

The outstanding symptom of involvement of nerve roots is pain, which is usually characteristic and pathognomonic.¹⁸ It may precede any other symptoms by months or years, it may be constant or intermittent, persist in a localized region, and radiate over the involved nerves. It is usually lancinating, and is aggravated by coughing, sneezing, lifting and straining at stool, and it invariably awakens the patient from four to six hours after he has retired. It often becomes so severe as to compel him to walk the floor or to sleep in a sitting position. The mechanism that produces this pain apparently is the ball-valve action of the tumor, which is forced downward by the increased pressure of cerebrospinal fluid above it, thus producing traction directly or indirectly on the nerve roots. Unfortunately, many of the patients are treated for neuritis, muscular rheumatism, or syphilis, and some have been thought to have had hysteria. The importance of recognizing or suspecting the first, or painful, phase in the development of tumors of the spinal cord was emphasized in a recent survey by Craig,¹³ in which 10 per cent of the patients who had root pain had been operated upon for some thoracic or abdominal lesion other than an intraspinal tumor.

The symptoms which develop in the second symptomatologic phase, the phase of beginning compression of the spinal cord, differ from those of the first phase in that neurologic evidence of compression of the cord now becomes evident. The symptoms may develop simultaneously with the existence of pain,¹³ or they may develop without pain in a small percentage of cases. If the tumor is situated anterolaterally, the symptoms will progress and produce the Brown-Séquard syndrome, a homolateral paralysis of the muscles below the level of the lesion, with impairment of tactile and deep sensibilities on the same side, together with loss or diminution of pain and temperature on the opposite side. If the posterior columns of the cord are the first to be compressed by the tumor, the deep sensibility is decreased and ataxia appears. Sensory disturbances resulting from compression of the cord are gradual in onset, and progress upward to a transverse level corresponding to the segment of the cord that is compressed. At the lower end of the spinal cord other difficulties may be encountered. The relative shortening of the cord incident to growth, and the emergence of the roots through the anterior foramina of the sacrum often make it extremely difficult to determine whether there is a tumor of the conus medullaris, of the cauda equina, or of the sacrum. The objective findings may be the same. In this group studies with radiopaque oil are valuable in localizing and differentiating the lesion. Paralysis below the level of the tumor comprises the third symptomatologic phase, and is caused by extreme compression of the cord.¹² The paralysis is usually complete, sensory functions are entirely lost, trophic disturbances are present, and there is definite loss of control of both vesical and rectal sphincters.

Intramedullary tumors rarely produce pain, but pass directly into the second symptomatologic phase. The sensory and motor disturbances are progressive until a definite transverse level becomes evident. The upper sensory level is less distinct than that produced by extramedullary tumors. Increased reflexes and loss of vesical and rectal control appear early in the symptom-complex^{1, 14}

Examination—The symptoms which play important parts in the diagnosis of intraspinal lesions emphasize the necessity of a comprehensive history in all cases. Following the taking and recording of the history, a detailed general, as well as a neurologic, examination is necessary. These examinations should include such special features as spinal puncture, Queckenstedt studies, and roentgenograms of the spinal column, with or without the introduction of iodized oil.

Neurologic Examination—In the case in which tumor of the spinal cord is suspected there is no investigation so important as complete neurologic examination. The information elicited by a detailed testing of reflexes, muscular strength, muscular tonus, sensory acuity, gait, coordination, and balance tends to distinguish between degenerative diseases and compression of the cord.

Spinal Puncture—This examination is very important, because it reveals information concerning the physical properties and the hydrodynamic properties of the spinal fluid,⁸ and allows its chemical reactions to be determined.² The puncture is usually performed at the fourth lumbar interspace, and before any fluid is removed the intraspinal pressure is estimated by means of Ayer's water manometer, which normally registers between 12 and 15 cm. As soon as the pressure has been estimated, Queckenstedt's test is made. This consists of reading and studying the rate of rise of the cerebrospinal fluid in the manometer following compression of both internal jugular veins. Sudden rise and rapid fall of the fluid on compression of both internal jugular veins indicate free flow of cerebrospinal fluid within the subarachnoid space. Slow rise and fall of fluid or its failure to rise on compression of the jugular veins suggests partial or complete intraspinal block.

Inability to obtain fluid at the fourth lumbar interspace may signify that the tip of the needle has failed to enter the subarachnoid space, that fluid is absent, or that there is a tumor at this level. Puncture should be made at another level, and it may be necessary to make multiple punctures. Occasionally, it is necessary to combine cisternal puncture with lumbar puncture.

Spinal block if it results from tumor, frequently causes an increase in the concentration of globulin in the cerebrospinal fluid below the tumor. The fluid may also be xanthochromic¹⁷ (From's syndrome²¹). The shade of yellow may vary and occasionally the fluid above a block is decidedly yellow. The cell count is usually normal, but pleocytosis may occur if the tumor is situated in the spinal canal below the conus medullaris. This may help in distinguishing neoplasms from inflammatory lesions.

The presence of partial or total subarachnoid block is not pathognomonic of intraspinal tumor, since previous attacks of meningitis, acute myelitis, injuries to the vertebrae, or spinal deformities are all capable of interfering

with the free flow of cerebrospinal fluid. It is, however, apparent that the finding of partial or total block is extremely valuable in diagnosis when the block is accompanied by a history of root pain, and with a negative history of inflammation or trauma of the spinal cord.

Roentgenographic Examination—Roentgenograms should be made of anteroposterior and lateral aspects of the vertebral column.²² These should be supplemented by stereoscopic and oblique views, localized at the level where, on clinical grounds, a tumor has been suspected. According to Camp and Adson,¹⁰ evidence of erosion of the vertebral pedicles, laminae, and lateral and spinous processes caused by pressure usually is discernible before such erosion is evident in the body of the vertebrae. In general, roentgenologic evidence of changes resulting from tumors of the spinal cord consists of shadows indicative of erosion secondary to direct pressure, invasion by the tumor,

LOCATION OF 557 CLASSIFIED INTRASPINAL NEOPLASMS TO JAN 1, 1939

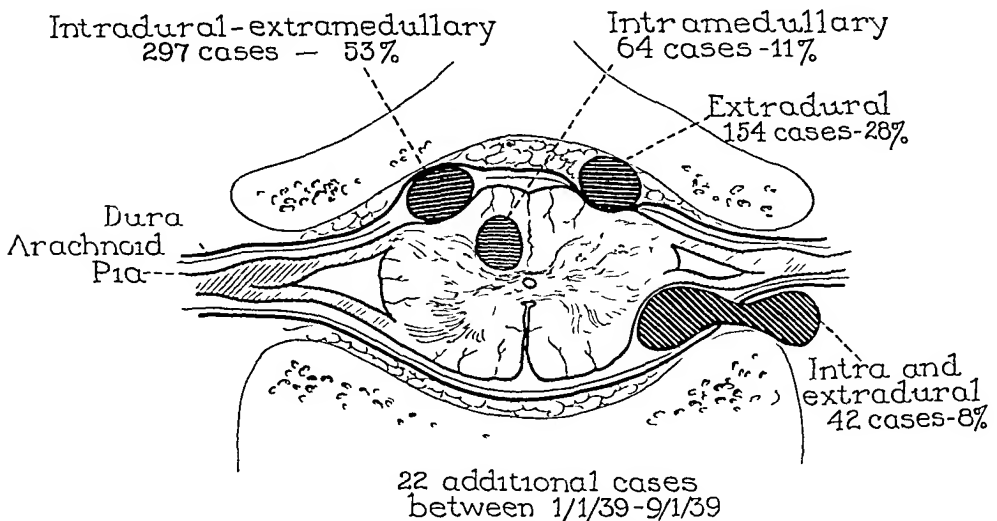


FIG 1—Location of 557 classified intraspinal neoplasms, to January 1, 1939

destruction caused by benign or malignant tumor of the bone, metastatic diseases and hyperostosis.⁹

Study with Radiopaque Oil—In addition to the roentgenologic evidence of tumors which is apparent in routine examination of the spinal column, fluoroscopic and roentgenographic study by the use of radiopaque oil has furnished much additional information in diagnosis and localization of intraspinal tumors. Injection of 5 cc of iodized oil into the subarachnoid space, either through cisternal puncture or lumbar puncture, allows visualization under the fluoroscope of the patency or lack of patency of the subarachnoid space. Fluoroscopic examination of the slowly moving oil is superior to examination of a roentgenogram, since the roentgenologist often sees the diversion of the current of oil around the tumor. However, roentgenograms should be made for confirmation of the levels where tumors are suspected to be. Intramedullary tumors are identified by division of the oil into two currents, one on each

side of the cord Use of the heavier oils avoids their ascent into the cisterns and ventricles Because introduction of these oils invariably produces irritation of the meninges, and occasionally radiculitis, they should be used only to localize tumors definitely After the oil has been injected the patient should

CLASSIFICATION OF 557 INTRASPINAL NEOPLASMS

Neurofibromas - 163 cases - 29%

Meningiomas - 140 cases - 25%

Intramedullary tumors - 64 cases - 11.5%

Sarcomas, etc. - 55 cases - 10%

Extramedullary hemangioendotheliomas, etc. - 47 cases - 8.5%

Extramedullary ependymomas (filum) - 32 cases - 6%

Chordomas - 23 cases - 4%

Miscellaneous extramedullary tumors - 33 cases - 6%

Fig 2—Classification of 557 intraspinal neoplasms

be placed prone on the fluoroscopic table, and the flow of oil should be observed when he is tilted in various positions, from horizontal to perpendicular Experience with the use of radiopaque oil in the diagnosis of tumor of the spinal cord has indicated that oil should be used infrequently only when tumors are suspected, and that the oil should be removed at operation whenever possible The presence of extramedullary tumors usually is indicated by definite arrest of the flow of lipiodol If there is no tumor or compression of the cord the oil descends and remains permanently in the sacral cul-de-sac³²

Pathologic Considerations—Up to January 1, 1939, there had been performed at the Mayo Clinic operations for 557 verified intraspinal neoplasms (Fig 1) These lesions have been classified pathologically and grouped according to situation (Figs 2 and 3) It is apparent that the distribution of

GENERAL DISTRIBUTION OF 557 CLASSIFIED INTRASPINAL NEOPLASMS

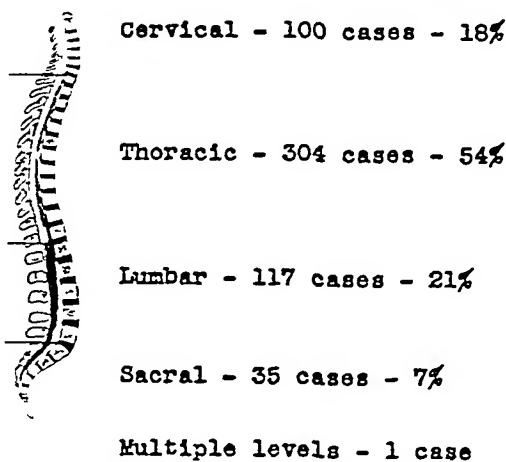


Fig 3—General distribution of 557 classified intraspinal neoplasms

these tumors with reference to the spinal axis has no predilection for any one region

Neurofibromata constitute the largest single group (Fig 4) *Meningiomas* compose the second largest group, and their primary distribution in the thoracic region is shown in Figure 5 *Intramedullary Tumors* The various

LOCATION AND DISTRIBUTION OF 163 NEUROFIBROMAS

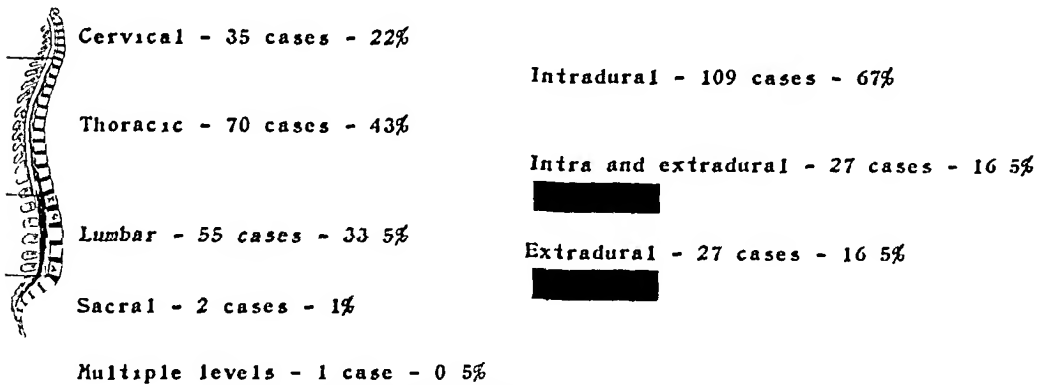


FIG 4—Location and distribution of 163 neurofibromata

LOCATION AND DISTRIBUTION OF 140 MENINGIOMAS

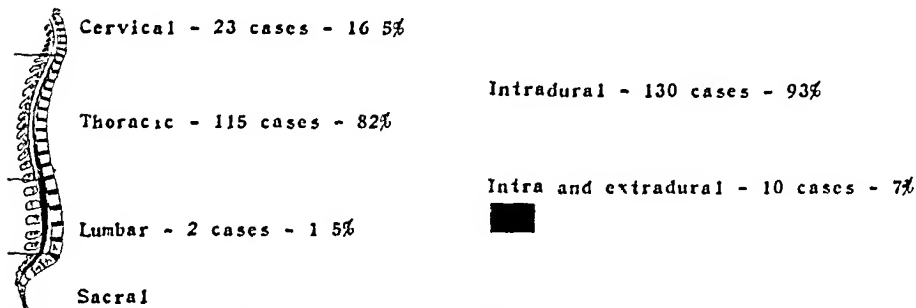


FIG 5—Location and distribution of 140 meningiomas

types of tumors represented in the group of 64 classified intramedullary tumors⁵ are best illustrated by referring to Table I, and their situation is illustrated in Figure 6

DISTRIBUTION OF 64 CLASSIFIED INTRAMEDULLARY TUMORS

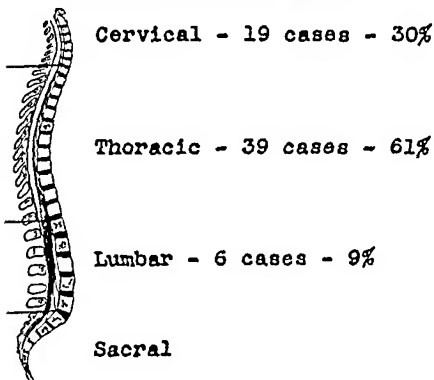


FIG 6—Distribution of 64 classified intra medullary tumors

The *ependymomata* are fairly evenly distributed throughout the spinal cord (Fig 7) Half of them arise from the spinal cord proper and the remaining half from the filum terminale⁶ *Vascular tumors* form a group including the hemangio-endotheliomata and heman-giomata, and their distribution and situa-tion are illustrated in Figure 8^{4, 19} *Chor-domata*, as previously stated, may be situ-ated in any portion of the spinal column, but they have a predilection for the sacral region (Fig 9) *Sarcomata*, under the heading "sarcomas," are included in a miscellaneous group of 55 sarcomatous

INTRASPINAL TUMORS

lesions consisting of lymphosarcomata, myelosarcomata, giant cell sarcomata, Hodgkin's disease, osteogenic sarcomata, *etc* Eleven per cent are situated in the cervical region, 56 per cent in the thoracic region, 22 per cent in the lumbar region, and 11 per cent in the sacral region Ninety-one per cent

LOCATION AND DISTRIBUTION OF 65 EPENDYOMAS

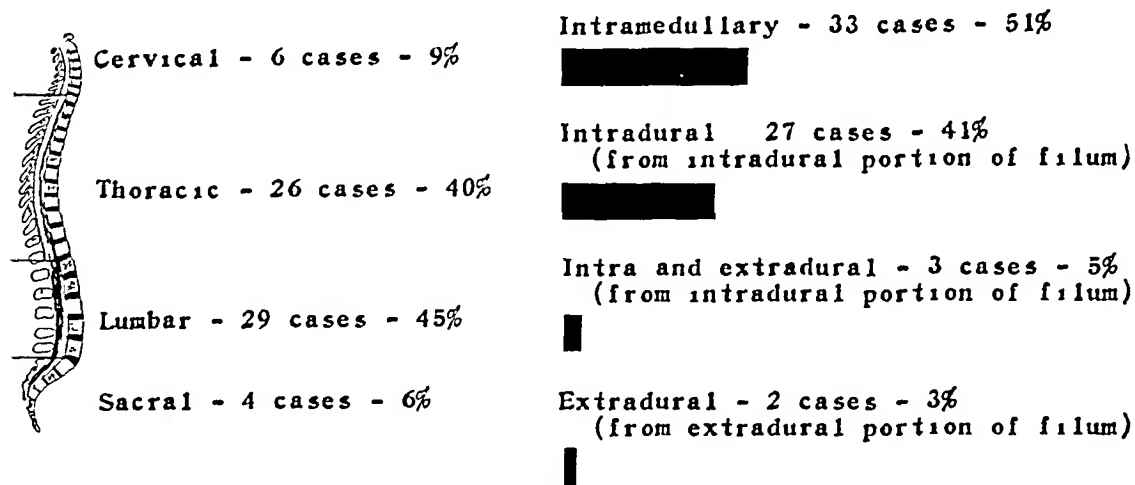


FIG 7—Location and distribution of 65 ependymomata

LOCATION AND DISTRIBUTION OF 52 BLOOD VESSEL TUMORS

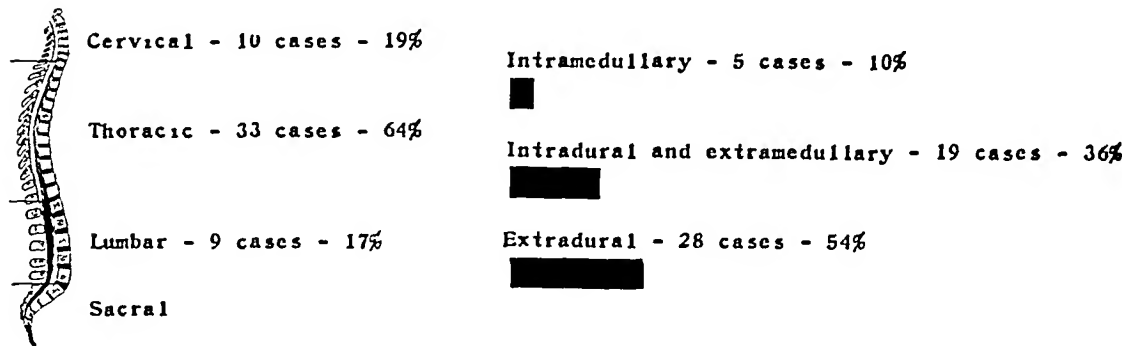


FIG 8—Location and distribution of 52 blood vessel tumors

TABLE I

CLASSIFICATION OF 64 INTRAMEDULLARY NEOPLASMS

Tumor	Number	Per Cent
Ependymoma and ependymblastoma	33	51 0
Astrocytoma and spongioblastoma polare	10	15 5
Oligodendrogloma and oligodendroblastoma	3	5 0
Spongioblastoma multiforme	3	5 0
Medulloblastoma	3	5 0
Ganglioneuroma and neuroblastoma	2	3 0
Hemangio-endotheliomata, etc	5	7 5
Melano-epithelioma	3	5 0
Fibrolipoma	1	1 5
Neurofibroma	1	1 5
Total	64	100 0

were situated extradurally, 5 per cent were intradural and extradural, and 4 per cent were intradural and extramedullary

Miscellaneous Extramedullary Tumors—Included in this group were six astrocytomata, one spongioblastoma multiforme, two ganglioneuromata,²⁵ six chondromata, two osteomata, three lipomata, two fibromata, two dermoids and one teratoma

LOCATION AND DISTRIBUTION OF 23 CHORDOMAS

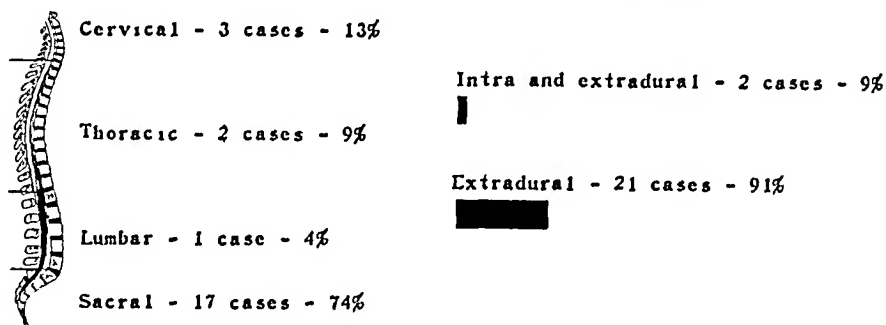


FIG 9—Location and distribution of 23 chordomata

LOCATION OF 377 NON-NEOPLASTIC INTRASPINAL MASS LESIONS TO JAN 1 1939

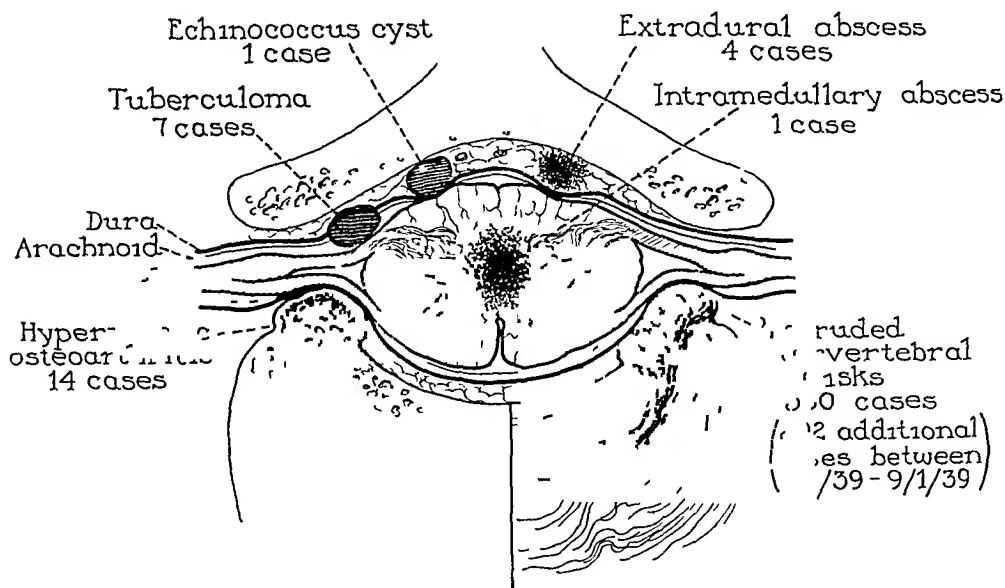


FIG 10—Location of 377 nonneoplastic intraspinal mass lesions, to January 1, 1939

In addition to the described verified intraspinal tumors, there were 468 additional intraspinal lesions which produced irritation or compression on the nerve roots or the spinal cord, suggesting, clinically, the possible existence of an intraspinal tumor or compression of the nerve roots and spinal cord by a nonneoplastic lesion (Fig 10). Of the 468 lesions there were 64 intramedullary lesions, presumably tumors or cysts of the spinal cord, which were not identified by biopsy. There were 29 additional, unclassified lesions situated within the spinal canal. The tissue removed to date has not been pathologi-

cally classified. In this same group of 468 cases, there were 377 nonneoplastic lesions, which includes protruded intervertebral disks, osseous compression of the roots and spinal cord and suppurative lesions (abscesses) within the spinal canal^{15, 34}

Surgical Consideration—The technic of a laminectomy has become standardized and, therefore, a detailed description is unnecessary²⁰. The anesthetic method we have found most suitable, after employing a variety of them, is that in which the ether is dropped onto an open mask which is held over a Magill intratracheal tube. The intratracheal tube is introduced as soon as the patient has been anesthetized with nitrous oxide and ether. In proceeding with a laminectomy one should make sure of the localization of the lesion, and bear in mind that unless the lesion has been localized by a roentgenogram the cord levels are situated above the corresponding osseous segments. A subperiosteal elevation of the periosteum and muscles will result in less bleeding than a lateral reflection of the erector spinae muscles by sharp dissection. Extreme care should be taken in removing the laminae from the tumor, in order to avoid additional trauma to the cord. The surgeon should also have in mind that dural pulsations will be detected above the tumor but will be absent below it, since this observation will direct him in extending the laminectomy in the proper direction in order to expose and remove the growth properly. Laminectomies performed in the thoracic and lumbar regions usually consist of removing both laminae and the spinous processes of from two to three vertebrae. However, it frequently becomes necessary to extend the laminectomy for longer distances when removing ependymomata of the filum terminale or neurofibromata of the caudal fibers. The tips of the spines, in immediate approximation above and below the site of laminectomy, are also removed in order to eliminate any bony prominences.

Hemilaminectomy is definitely indicated in removing lesions of the cervical portion of the cord, since bilateral laminectomy with removal of the spines may give rise to a slipping forward of the cervical vertebrae, one upon the other, and the entire cervical group upon the first thoracic vertebra. When it does become necessary to perform bilateral cervical laminectomy, extreme care should be exercised in closing the incision so that the cut edges of the ligamentum nuchae will be accurately approximated. When slipping occurs, the patient will exhibit progressive signs of a lesion of the transverse portion of the cord. Lateral roentgenograms will quickly confirm the suspicion. It then becomes necessary to place the patient in bed on his back with extension applied to the head. As soon as the symptoms subside, a cancellous bone graft taken from the crest of the ilium should be inserted along the freshened bone edges of a previous laminectomy³. The graft should be extended for a distance of one to two laminae above and below the site of the former laminectomy. Grafts should be placed well laterally to avoid pressure on the spinal cord. In a few instances in which the laminectomy has included the atlas and axis, the graft is brought in contact with the occipital bone. This same procedure has been employed to relieve the pressure on the upper

part of the cervical portion of the cord when an anterior slipping of the atlas on the axis has taken place following fracture or destruction of the odontoid process of the axis

Neurofibromata—Since neurofibromata may arise from the nerve roots within the dura, from the roots as they penetrate the dura, or from the peripheral nerve just lateral to the dura, it will be found that these lesions may be situated wholly within the spinal canal, intradurally or partly within the dura, and partly outside of the dura, or they may be situated extradurally with an enlargement and a protrusion into the intervertebral foramen, or they may present the typical dumb-bell appearance, with one portion within the spinal canal just described, with a similar projection beyond the intervertebral foramen. Neurofibromata situated in the spinal canal, even though they have eroded the bone around the intervertebral foramen, usually can be removed during a one-stage operation. Those which are dumb-bell tumors and are situated in the cervical region of the canal are more effectively removed through two separate incisions, and the extraspinal portion of such a tumor is removed first through a lateral cervical incision. This incision is closed and is then followed by laminectomy, frequently hemilaminectomy, through which the intraspinal portion is removed.

Many of these so-called dumb-bell tumors involve the thoracic nerves, and the extraspinal projection may vary in size from a small nodule to a tremendous mass the size of a baby's head.²⁰ It is not infrequent for the thoracic portion not only to erode the bone around the intervertebral foramen, but also to erode the pedicles, transverse processes of the vertebrae, and portions of ribs. The erosion produced by a neurofibroma is similar to that produced by a meningioma, since it results in smooth erosion and not in the irregular, ragged type of destruction so characteristically produced by metastatic tumors.¹¹ When a malignant change takes place in a neurofibroma, the bony invasion and destruction resembles that of a primary malignant lesion and recurrence is almost sure to take place even though a radical removal has been performed.

Since both laminectomy and thoracotomy are major operations, it has been our practice to perform laminectomy and remove the intraspinal portion of the tumor first and wait for the patient thoroughly to convalesce from the first operation before performing the second. This period of waiting usually extends over a month or two. There is one precaution that the thoracic surgeon has to consider and that is to effect complete hemostasis following the removal of the intrathoracic portion of the neurofibroma. Moreover, he must be especially cautious not to apply forceps or to introduce packs along the spinal column where the defect exists, a procedure which might cause trauma to the cord. We have found it advantageous at the Clinic for both the neurologic and thoracic surgeons to assume joint responsibility¹⁶ in order that one may understand the objectives of the other and observe what has been done so that the strength of the patient may be evaluated before the second stage of the operation is begun.

Most neurofibromata within the spinal canal have a tendency to degenerate and become cystic, and in a number of instances, in the lumbar region, the neurofibromata have been known to grow to considerable size, eroding laminae, pedicles and bodies of the vertebrae without producing signs of complete paraplegia. On visualizing these cystic tumors, it is observed that the dura and extradural fat have become atrophic, that the lining of the cyst and the dura are almost inseparable, and that a puncture of the cyst has resulted in escape of the yellow fluid and collapse of the wall of the tumor, making it rather difficult for the surgeon to identify the lesion, but, on further observation, it is usually found that the root is involved and also the remaining nubbin of tumorous tissue. Neurofibromata involving the roots of the spinal cord are usually singular, but occasionally may be multiple and may be part of von Recklinghausen's disease.

Meningiomata—Meningiomata, fibroblastomata originating from the arachnoid, may be situated in any portion of the spinal canal and be located in any part of the circumference of the canal about the cord, producing pressure at the point of origin. The most common site of origin of such a lesion is about a nerve root, but not originating from it. The meningeal attachment is usually rather limited, although the tumor may grow in all directions without becoming attached to the cord. Occasionally, the meningioma is sessile in type, instead of being rounded or oval in shape. When the tumor is sessile it involves a large portion of the dura surrounding the cord. Usually it is possible to remove the tumor mass *in toto*, but in doing so it is necessary to remove a portion of the arachnoid and dura, since they are intimately attached at the site of origin. If the surgeon fails to do this, recurrence will develop. Hemostasis is most effectively accomplished during the removal of the tumor by applying electrocoagulation to the base of the tumor extradurally. Care must be taken not to overheat the tumor, since this could result in impairment of the circulation of the cord. In a few instances, in which the tumor is situated anterior to the cord, it may become necessary to remove the tumor by the piecemeal method in order to avoid undue traction or pressure on the spinal cord.

Following the removal of meningiomata and neurofibromata, the surgeon frequently observes marked indentations of the cord. These indentations may have compressed the cord to less than half its normal size, but we have also observed that even though the indentation has markedly flattened the cord, complete recovery of the patient will take place if the blood supply of the cord has not been destroyed.⁷ The gradual growth of the tumor will have produced destruction and absorption of the myelin before destruction of the axis cylinder, results which explain why recovery takes place. As a rule, it is not necessary to attempt repair of dural defects resulting from the necessary removal of small portions of the dura with the attached tumor, if the surgeon is careful to maintain absolute hemostasis. We frequently cover the defect with a portion of animal membrane (prepared peritoneum of the ox) to prevent the entrance of blood into the arachnoid or subdural spaces.

This same rule applies to dual defects resulting from the removal of other tumors that are adherent to the dura

Intramedullary Tumors—The surgical consideration of intramedullary tumors is almost the same for the entire group of lesions, even though they may vary in their pathologic classification. Most of them are glomatous in origin. The largest group is the ependymomata. These tumors originate from the ependymal cells lining the central canal. Several hemangio-endotheliomata have been found to be situated within the cord, one large intramedullary lipoma and one neurofibroma were found to have invaded the cord for an unusually long distance. Unless cystic degeneration has taken place in or about the tumor, the surgical approach is the same for all intramedullary tumors. Cysts are readily emptied, as is also the cystic cavity of a syringomyelia, and occasionally the surgeon is able to maintain constant drainage or prevention of filling by resection of the wall of the cyst, if it is possible to approach the cyst through the dorsal midline of the cord. The introduction of a small strip of folded gutta-percha held in place by a silk ligature has also been useful in the prevention of refilling of the cyst.

It is impossible completely to remove glomatous lesions of the cord, since there is no line of demarcation permitting enucleation. A heroic attempt at removal is more likely to increase the symptoms of paraplegia than it is to reduce those already present. When such a condition does exist, it has been learned that a longitudinal section of the cord, extended into the mass of the tumor for its entire length, has proved to be of value in allowing the tumor slowly to extrude itself and thus relieve pressure on the noninvolved nerve tracts.²³ Hemangio-endotheliomata frequently can be removed by exposing them through a longitudinal incision of the cord, bearing in mind the fact that a dorsal midline incision without injury to the dorsal artery produces less motor disturbance than do lateral or anterior incisions. Although most intramedullary tumors are elongated masses which increase the size of the cord so that it has the appearance of a sausage, ependymomata of the spinal cord proper are found to be the longest of the group. Since they are fairly well circumscribed, although not definitely encapsulated, they do lend themselves to radical removal.

Ependymomata of the Filum—Ependymomata originating within the filum, or even as high as the tip of the conus medullaris, represent a rather interesting group of tumors, since they may grow to considerable size, filling the lumbar and sacral canals before they produce paraplegia. These tumors are not encapsulated, but they are surrounded by pia mater. They produce marked erosion of the bone without invading it, grow in between the nerve roots of the cauda equina, increase the size of the lumbosacral canal, may enlarge the intervertebral foramen, and grow into the soft tissues of the back—but they apparently do not metastasize. The surgical problem that faces one, then, is to perform extensive laminectomy in order thoroughly to uncover the tumor, and then to proceed with careful dissection and removal of the tumor without impairing the blood supply or damaging the nerve roots.

Complete removal will result in a cure, failure to do so will result in recurrence

Vascular Tumors—Under the heading of “vascular tumors” we include hemangiomata and hemangio-endotheliomata. These may be situated extradurally, subdurally (but extramedullary), and intramedullary. They are usually benign and are fairly well encapsulated, but they are extremely vascular. The extradural lesions are flattened, elongated masses, whereas the intradural lesions are usually oval in appearance. The vascular tumors are usually operable, but extreme care is necessary in removing the tumor in order to avoid injury to the blood supply of the spinal cord. In addition to the typical vascular tumor, we have encountered several vascular lesions which would have to be classified as “varicosities of the cord” and “arteriovenous fistulae.” In these instances, the task of the surgeon is to reduce the varicose mass in size by ligation and resection and by the employment of electrocoagulation, he should bear in mind, however, that the blood supply of the spinal cord itself or of the nerve roots must not be injured.

Chordomata—Chordomata originate from the notochord, and although their site of predilection is the sacrum, and the clivus blumenbachii, they may originate in other portions of the spinal column. These tumors erode and invade the bony structure and fill the spinal canal, producing compression and destruction of the nerve root and the spinal cord. They are primary malignant tumors, but since their growth is slow and is accompanied by pain, the surgeon is frequently justified in attempting radical removal. Although situated in the sacrum, these tumors produce an explosive type of enlargement, that is, an erosion with an invasion of the bone and elevation of isolated fragments of bone on the periphery of the tumor. Following radical resection of these tumors, roentgenotherapy appears to offer additional relief in controlling the growth of the tumor and in retarding the process of recurrence.

Bony Lesions Which Produce Compression of the Cord—Hemangiomata of the vertebrae result in osteoporosis and flattening of the body with compression of the cord. Occasionally, unilateral laminectomy, acting as decompression, offers some relief, but if such a procedure is employed, a cancellous bone graft should be inserted along the unoperated side.

Neurologic symptoms accompanying *tuberculous* involvement in the body of the vertebrae are usually relieved by placing the patient in hyperextension on a specially adapted frame. As the symptoms subside, the orthopedic surgeon usually inserts a bone graft as an additional support to prevent a collapse of the body of the vertebrae. However, if the neurologic symptoms fail to improve after hyperextension, the surgeon is justified in carrying out hemilaminectomy for decompressive purposes. Usually there is found an increased amount of granulation tissue within the extradural fat. Although removal of such tissue may be justifiable, extreme care should be taken to avoid an injury to the dura, since the dura acts as a barrier to the invading tubercle bacilli.

Foreign-Body Giant Cell Tumors may be recognized by roentgenographic observation. Since these lesions are benign, they lend themselves to surgical treatment which consists of laminectomy and removal by curet of the contents within the cystic cavity. This, in turn, relieves pressure on the meninges and spinal cord.

Myelomata—At the onset, spinal myelomata may be single or multiple. When a single myeloma is encountered, the surgeon is tempted to try radical removal in order to decompress the spinal cord, but the procedure is rarely justifiable, since recurrence is sure to take place and other lesions soon follow. Roentgenotherapy has proved of very little value.

Osteogenic Sarcomata—Although usually single at the onset, osteogenic sarcomata of the spinal column will recur and metastasize. The temporary relief obtained by radical removal, in order to decompress the spinal cord, is occasionally indicated, especially if osteogenic sarcomata involve the laminae and spinous processes.

Osteochondromata—These may be benign at the onset but frequently become malignant, they originate in the intervertebral disk and the adjacent vertebrae. Growth of such a lesion into the spinal canal produces symptoms similar to those of any extradural tumor,³³ a point which emphasizes the fact that early recognition is essential and that a radical operation should be performed even though it becomes necessary to insert a bone graft to support the noninvolved portion of the spinal column.

Paget's Disease—In a number of instances, the squashing process of this disease produces radiculitis and, occasionally, symptoms of compression of the cord. Again, it is doubtful whether decompression of the cord is indicated, since the relief obtained is of such temporary nature.

If either *hypertrophic arthritis* or *osteitis* extends into the spinal canal, the roots may become involved and the spinal cord compressed, with the resulting symptoms of transverse myelitis.³¹ If it is possible to determine by neurologic and roentgenographic examination that the process is fairly well localized, and if it has been recognized in the early stages of the disease, it is possible to obtain satisfactory results by means of wide and extensive laminectomy over the involved portion of the cord. Occasionally, it becomes necessary to unroof the nerve roots as they pass through the intervertebral foramina.

Protruded Intervertebral Disks—The subject of protruded intervertebral disks has received unusual attention in the last few years,^{26, 27, 28, 30} due to the fact that tumor-like masses can be recognized by roentgenologic examination of the spinal canal by employing radiopaque oils or air. The finding of these masses in patients suffering from chronic, recurring sciatica has led to exploratory laminectomies and removal of the masses which were producing pressure on the nerve roots. The relief obtained from the surgical treatment of this condition has more than justified these newer procedures in the treatment of chronic, recurring sciatica when physiotherapeutic measures have failed. The lesions occur as the result of a tear in the annulus fibrosus, and

a rupture of the intervertebral disk with an expulsion of a portion or all of the nucleus pulposus. Although the condition had been recognized, and occasionally treated, for a number of years, its importance was not emphasized until the introduction of roentgenographic studies made with the aid of radiopaque oil. These tumor-like masses, the nucleus pulposi, are not neoplastic, even though they produce symptoms similar to those caused by intraspinal tumors. After recognizing the lesion by the aid of the clinical history, neurologic observations and roentgenographic studies, they can be readily removed through hemilaminectomy, removing a portion of one and occasionally two laminae at the site of the lesion. The ligamentum flavum has frequently been ruptured and hypertrophy has taken place, so that it becomes necessary to remove the affected ligamentum flavum with the protruded disk. The involved spinal root is found to be compressed between the protruded portion of the nucleus pulposus and the pedicle of the vertebrae opposite the intervertebral foramen. Removal consists of dissecting free the edematous root and retracting the dura toward the midline, following which the completely prolapsed nucleus pulposus may be found to be lying free within the canal and can be removed without further dissection. If the protrusion is incomplete, it may be necessary to use a sharp knife or even a curet to remove the partially dislodged nucleus pulposus. The dura is not opened unless radiopaque oil has been used, in which event the oil should be thoroughly removed before closing the incision. The protruded masses are usually single, may be multiple, and are usually situated lateral to the posterior longitudinal ligament. They have occasionally been found to be situated in the midline when the protrusion is situated at the lumbosacral junction. When that does occur, transdural removal may be required. The largest number of protrusions occur in the lumbar and lumbosacral regions, but they may occur in any part of the spinal column. The second most common site of occurrence is the cervicothoracic region.

Hodgkin's Disease or Echinococcus Cysts may enter the spinal canal through the intervertebral foramen, and when they do so they are found to be situated extradurally, producing symptoms referable to the cord by extradural pressure. Usually, these masses can be removed by means of routine laminectomy without opening the dura, just as a surgeon would remove an extradural neoplasm. If the lesion is recognized as that of Hodgkin's disease, there being other manifestations, it is wise to employ a course of deep roentgenotherapy before resorting to laminectomy. On the other hand, if the symptoms of paraplegia are very pronounced, it may be unwise to defer laminectomy. In some instances, the operation has been performed first and then the roentgenotherapy has been employed.

Metastatic Lesions of the Spinal Column—Metastatic lesions of the spinal column produce symptoms similar to those of intraspinal tumors except that they develop much more rapidly than do benign lesions. They occur at a later age than the average intraspinal tumor does, which should make the surgeon extremely careful during examination of the patient to determine, if

possible, the presence of a primary lesion. Exploratory laminectomy is rarely indicated, since removal of one metastatic nodule accomplishes so little that it is scarcely justifiable. Occasionally, an operation must be performed when no primary lesion has been located, and there is some doubt as to whether the lesion is malignant.

Inflammatory Lesions, Chronic Radiculitis and Meningomyelitis—These are capable of producing symptoms simulating intraspinal tumors, but fortunately, studies of the spinal fluid, of jugular pressure (Queckenstedt test), which are employed to determine the presence or absence of an intraspinal block, and roentgenographic examinations made with the aid of radiopaque oil have made it possible to differentiate these lesions from true neoplasms. It is obvious that surgical treatment is not indicated in this group of lesions.

Suppurative Lesions—Suppurative lesions, such as extradural and intramedullary abscesses, rarely occur and can be differentiated and localized by the usual diagnostic methods, taking into consideration, of course, the fact of the accompanying suppurative infection and the rapidity with which symptoms of compression or destruction of the cord result. Surgical drainage has proved to be most effective in the treatment of this condition, but if it is employed, it should be instituted before the symptoms of transverse myelitis are complete.

Postoperative Care—Following the operation, the patient is placed in bed in the lateral position on pillows, to avoid undue pressure on the tips of the shoulders and on the hips. It is preferable to turn the patient from side to side and on the abdomen, rather than to allow him to lie on his back, because sweating may result in maceration of the skin and contamination of the incision, and may interfere with primary union. The patient, otherwise, is treated as is the average surgical patient. If urinary incontinence is present, it is safer to insert an indwelling catheter rather than to repeat catheterization daily. As an additional prophylactic measure, the patient should receive 15 Gm. of sulfanilamide daily. The catheter should be changed every four or five days, and the bladder irrigated twice daily with an antiseptic solution. Usually, daily doses of mineral oil combined with milk of magnesia are administered to prevent distention and fecal impaction. In addition, a daily enema is necessary. The patient is kept in bed for two weeks, at the end of which period he is permitted to sit in the upright position in bed, he is subsequently allowed to be taken about in a wheel chair and to walk, if possible. The usual postoperative course continues for three weeks. Physiotherapy is advised if muscular cramps and motor weakness exist. Indwelling catheters should be removed permanently when the patient has recovered sufficient control of the bladder to empty it thoroughly.

Contractures and defensive reflex spasms are corrected and relieved during the period of convalescence by the application of Buck's extension to the feet and legs while the patient is in the reclining position. The recovery of motor, sensory, vesical, rectal and sexual functions takes place in the reverse order of their previous disappearance.

CONCLUSIONS

The frequent occurrence of primary intraspinal tumors, which are usually benign and operable, justifies thorough examination of all patients who complain of root pain or of progressive motor or sensory disturbance of the extremities. The diagnostic methods at our disposal will invariably affect the differential diagnosis. Surgical treatment, if it is to be instituted, should be employed before the patient becomes paralyzed.

REFERENCES

- ¹ Adson, A. W. Surgical Diagnosis of the Spinal Cord. In Graham, E. A. Surgical Diagnosis. Philadelphia, W. B. Saunders Company, 3, 899-949, 1930.
- ² Adson, A. W. The Diagnosis and Treatment of Surgical Lesions of the Spinal Cord. Proc. Internat. Assemb. Inter-State Post-Grad. M. A., North America, 125, 1935.
- ³ Adson, A. W., and Ghormley, R. K. Fixation of the Spine for Dislocation Following Removal of High-Lying Tumor of the Cervical Portion of the Spinal Cord. Proc. Staff Meet. Mayo Clin., 8, 297-299, May 17, 1933.
- ⁴ Adson, A. W., and Kernohan, J. W. Cranial and Cervical Chordomas. A Clinical and Histologic Study. Arch. Neurol. and Psychiat., 33, 247-261, February, 1935.
- ⁵ Adson, A. W., Kernohan, J. W., and Woltman, H. W. Intramedullary Tumors of the Spinal Cord. A Review of 51 Cases with an Attempt at Histologic Classification. Arch. Neurol. and Psychiat., 25, 679-701, April, 1931.
- ⁶ Adson, A. W., Kernohan, J. W., and Woltman, H. W. Gliomas Arising from the Region of the Cauda Equina. Clinical, Surgical and Histologic Considerations. Arch. Neurol. and Psychiat., 29, 287-305, February, 1933.
- ⁷ Adson, A. W., and Ott, W. O. Results of the Removal of Tumors of the Spinal Cord. Arch. Neurol. and Psychiat., 8, 520-537, 1922.
- ⁸ Ayer, J. B. Spinal Subarachnoid Block as Determined by Combined Cistern and Lumbar Puncture, with Special Reference to Early Diagnosis of Cord Tumor. Arch. Neurol. and Psychiat., 7, 38-52, January, 1922.
- ⁹ Camp, J. D. The Significance of Osseous Changes in the Roentgenographic Diagnosis of Tumors of the Spinal Cord and Associated Soft Tissues. Radiology, 22, 295-303, March, 1934.
- ¹⁰ Camp, J. D., and Adson, A. W. Roentgenologic Findings Associated with Tumors in the Spinal Canal. Proc. Staff Meet. Mayo Clin., 6, 726-729, December 9, 1931.
- ¹¹ Camp, J. D., Adson, A. W., and Shugrue, J. H. Roentgenographic Findings Associated with Tumors of the Spinal Column, Spinal Cord and Associated Tissues. Am. Jour. Cancer, 17, 348-372, February, 1933.
- ¹² Craig, W. McK. Spinal Cord Compression. Tumors and Allied Nontraumatic Conditions. Am. Jour. Surg., 12, 303-313, May, 1931.
- ¹³ Craig, W. McK. The Pain of Tumors of the Spinal Cord. West. Jour. Surg., 40, 56-63, February, 1932.
- ¹⁴ Craig, W. McK. Tumors of the Spinal Cord. Practitioners' Library of Medicine and Surgery, Chap. 22, 202-211, 1935.
- ¹⁵ Craig, W. McK., and Doyle, J. B. Metastatic Epidural Abscess of the Spinal Cord, Recovery after Operation. ANNALS OF SURGERY, 95, 58-66, January, 1932.
- ¹⁶ Craig, W. McK., and Harrington, S. W. Mediastinal and Intraspinal Perineural Fibroblastoma (Hour-Glass or Dumb-Bell Tumor) Removed by One-Stage Operation. J. A. M. A., 103, 1702-1704, December 1, 1934.
- ¹⁷ Cushing, H., and Ayer, J. B. Xanthochromia and Increased Protein in the Spinal Fluid Above Tumors of the Cauda Equina. Arch. Neurol. and Psychiat., 10, 167-193, August, 1923.
- ¹⁸ Elsberg, C. A. Tumors of the Spinal Cord and the Symptoms of Irritation and Com-

- pression of the Spinal Cord and Nerve Roots New York, Paul B Hoeber, Inc, 1925, 421 pp
- ¹⁹ Fletcher, E M, Woltman, H W, and Adson, A W Sacrococcygeal Chordomas A Clinical and Pathologic Study Arch Neurol and Psychiat, 33, 283-299, February, 1935
- ²⁰ Frazier, C H (with the collaboration of Allen, A R) Surgery of the Spine and Spinal Cord New York, D Appleton & Company, 1918, 971 pp
- ²¹ From, G Inflammations meningées avec reactions chromatique, fibrineuse et cytologique du liquide cephalo-rachidien Gaz d hôp, 76, 1005, 1903
- ²² Hampton, A O, and Robinson, J M The Roentgenographic Demonstration of Rupture of the Intervertebral Disk into the Spinal Canal after the Injection of Lipidol, with Special Reference to Unilateral Lumbar Lesions Accompanied by Low Back Pain with "Sciatic" Radiation Am Jour Roentgenol, 36, 782-803, December, 1936
- ²³ Horrax, G A Report on Removal of Extensive Ependymoma (Unpublished data)
- ²⁴ Ingraham, F D Intraspinal Tumors in Infancy and Childhood Am Jour Surg, 39, 342-376, February, 1938
- ²⁵ Kernohan, J W, Adson, A W, and Moersch, F P Neurogenic Tumors Arising from the Sacrum Arch Neurol and Psychiat, 41, 535-555, March, 1939
- ²⁶ Love, J G Intractable Low Back Sciatic Pain Due to Protruded Intervertebral Disks Diagnosis and Treatment Minnesota Med, 21, 832-839, December, 1938
- ²⁷ Love, J G, and Camp, J D Root Pain Resulting from Intraspinal Protrusion of Intervertebral Disks Diagnosis and Surgical Treatment Jour Bone and Joint Surg, 19, 776-804, July, 1937
- ²⁸ Mixer, W J, and Barr, J S Rupture of the Intervertebral Disk with Involvement of the Spinal Canal New England Jour Med, 211, 210-215, August 12, 1934
- ²⁹ Naffziger, H C, and Brown, H A Hour-Glass Tumors of the Spine Arch Neurol and Psychiat, 29, 561-584, March, 1933
- ³⁰ Naffziger, H C, Inman, Verne, and Saunders, J B deC M Lesions of the Intervertebral Disk and Ligamenta Flava, Clinical and Anatomic Studies Surg, Gynec and Obstet, 66, 288-299, February 15, 1938
- ³¹ Parker, H L, and Adson, A W Compression of the Spinal Cord and Its Roots by Hypertrophic Osteo-Arthritis, Diagnosis and Treatment Surg, Gynec and Obstet, 41, 1-14, July, 1925
- ³² Penfield, Wilder The Encapsulated Tumors of the Nervous System Meningeal Fibroblastomata, Perineurial Fibroblastomata and Neurofibromata of von Recklinghausen Surg, Gynec and Obstet, 45, 178-188, August, 1927
- ³³ Stookey, Byron Compression of the Spinal Cord Due to Ventral Extradural Cervical Chondromas Diagnosis and Surgical Treatment Arch Neurol and Psychiat, 20, 275-291, August, 1928
- ³⁴ Woltman, H W, and Adson, A W Abscess of the Spinal Cord, Report of a Case with Functional Recovery after Operation Brain, 49, 193-206, June, 1926

CERVICAL RIBS AND THE SCALENUS MUSCLE SYNDROME *

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By a study of comparative anatomy, one is able to tell why cervical ribs occur, to predict any anatomic arrangements such ribs may assume and, by further study of embryology, to tell why certain ribs produce symptoms¹

There are certain fish, such as skates and sea-horses, which have no ribs (Plate I, Fig 1) There are other fish, as the *Dipnoi*, which have ventral ribs incompletely surrounding the body cavity and lying just inside the peritoneum (Plate I, Fig 2) Still other fish, such as the shark and the ray, have only dorsal or pleural ribs There are a few fish, notably the *Ganoides Polypterus*, which have both ventral and dorsal ribs, two pairs of ribs to each vertebra (Plate I, Fig 3) These fish, therefore, represent connecting links in the evolution of ribs

The ribs of the *Urodela*, *e g*, the salamander, are forked, being attached in two places to the vertebrae (Plate I, Fig 4) In humans, one projection of this fork becomes the head and the other the tubercle of the rib

The first movable ribs are seen in the *Anura*, *e g*, frogs, as rudimentary movable stubs attached to the transverse processes of the vertebrae (Plate I, Fig 5)

The ribs of lizards and crocodiles are the first to show both a dorsal bony part and a sternal cartilaginous part (Plate I, Fig 6) Snakes have no sternum, all their ribs being of the "floating" type (Plate I, Fig 7) In birds all the ribs are ossified from the sternum to the vertebrae (Plate I, Fig 8) In mammals the sternal part of the ribs remains cartilaginous (Plate I, Fig 9)

There is a wide variation in the number of ribs in different animals Cervical ribs are often lacking in turtles, they are very short in many reptiles, and in birds the distal ends of these ribs are bent inward to protect the carotid arteries² Ribs vary in mammals from nine pairs in the bottle-nosed whale to 24 pairs in the two-toed sloth True ribs that reach the sternum vary from two pairs in the manatee to ten pairs in the spider monkey

That the number of ribs in man is slowly decreasing is proved by the following observations In fetal life ribs are temporarily present on the seventh cervical vertebra and all of the lumbar vertebrae Also, in the human embryo rudimentary ribs are attached to the sacral vertebrae Later on, these ribs fuse with adjacent transverse processes to form the lateral masses of the sacrum The eleventh and twelfth pairs of ribs are of the rudimentary floating type and fail to reach the sternum Lastly, we frequently find remnants of ribs in the cervical and lumbar regions It is these evolutionary

* Read before the New York Surgical Society, New York, N Y, April 26, 1939
Submitted for publication April 6, 1939

remnants, and in particular those of the cervical region, with which we are interested at this time. If these remnants are compared to those of the earlier forms, a surprising similarity is seen. Such ribs may resemble the insignificant

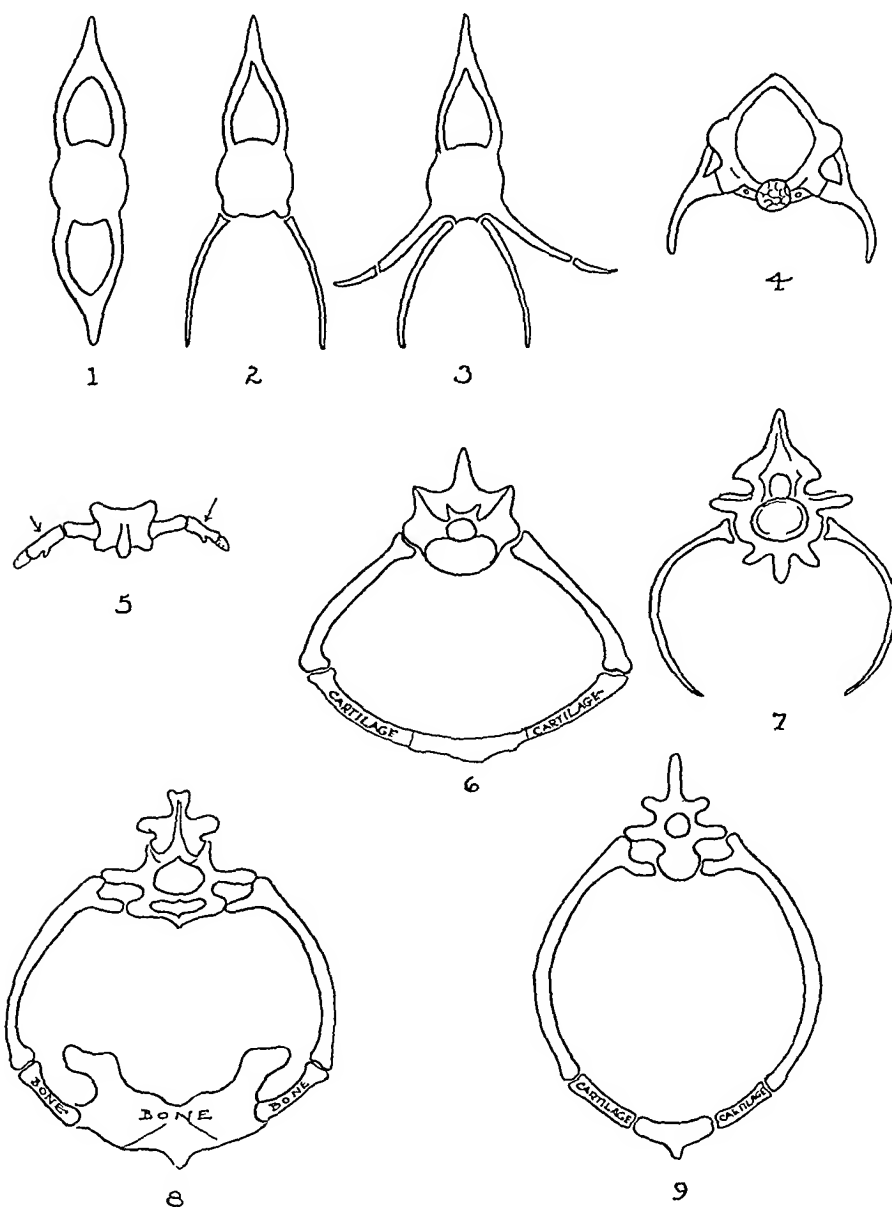


PLATE I—Vertebrae showing types of ribs on the basis of comparative anatomy (1) Fish with dorsal and haemal spines but no ribs (2) Fish with ventral or fish ribs (3) Fish with pleural and haemal ribs (4) Salamander with short pleural ribs which closely anticipate human ribs (5) Frog with insignificant movable rib tips (6) Iguana or lizard with dorsal bony part and cartilaginous ventral part (7) Ribs of rattlesnake as pure example of floating ribs (8) Bird ribs solid bone, attached to vertebrae and bony breast plate (9) Mammalian ribs with cartilaginous sternal parts

movable tips seen in frogs, or they may at times be completely formed ribs with a vertebral and sternal attachment, as found in some of the lower animals

Lumbar ribs are normal in gorillas and chimpanzees. They are, therefore,

called "gorilla ribs," and a fact not generally known is that they occur in man more often than do cervical ribs *

Why human beings get symptoms from cervical ribs, from high first ribs and from hypertrophied scalenus muscles can be well understood if one is familiar with the embryologic development and the anatomy of the structures about the upper end of the thoracic cage

In the first place, the developing upper extremity demands, or carries with it, large blood vessels and at least six spinal nerves in the form of the brachial plexus. In quadrupeds and human embryos these blood vessels and nerves along with the ribs come off more or less at right angles to, and hang downward, as it were, from the spinal column since the latter is carried parallel to the ground

When human beings begin to assume the upright position, the upper extremities begin to pull downward parallel to the spine instead of at right angles to it. The same is true of all of the viscera. The brachial plexus and subclavian vessels, being on the outside of the thoracic cage, thus straddle the first rib and actually press sufficiently on the latter to the point where, in human anatomy, grooves for these structures on the first ribs are always described³ (Fig 1). If a cervical rib is now introduced, either behind or under the brachial plexus and the subclavian vessels, pressure on these structures is only increased.

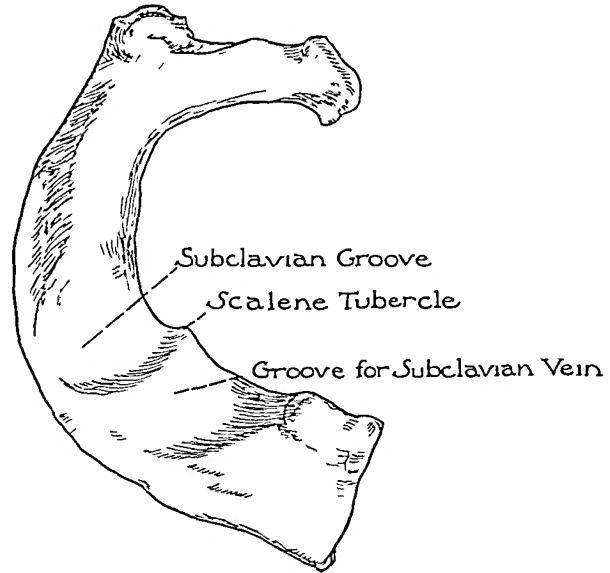


FIG 1—The normal first rib showing well worn grooves for the subclavian vessels on either side of the scalene tubercle. The grooves emphasize the amount of pressure caused by the vessels (after Gray)

Another factor producing symptoms is the action of the scalenus muscles during inspiration⁴. The medius is the largest and strongest. In deep respiration, this group of muscles is in full action, raising the first ribs upward along with the sternum. If the scaleni are hypertrophied, or if there is already pressure on the brachial plexus and subclavian vessels, either by an enlarged first rib or a cervical rib, symptoms from such pressure are only increased when this group of muscles is in action.

The thoracic cage in quadrupeds and human embryos is broader from front to back, whereas, in the human adult the cage is broader from side to side. This increased lateral diameter adds to the pull on the brachial plexus and the subclavian vessels as they go out and down the arm.

The clinical aspect of this paper has to do with the study of 31 cases. The anatomic types of these cases are shown in Plates II and III. Actual draw-

* For the references to comparative anatomy, the author has drawn freely from Herbert Eugene Walter's¹ book.

ings of the roentgenograms were made because they show the bony anatomy more clearly than do the films themselves

It will be seen that they fall into the following broad groups (1) Enlarged transverse processes, usually of the seventh cervical vertebra (2) Bi-

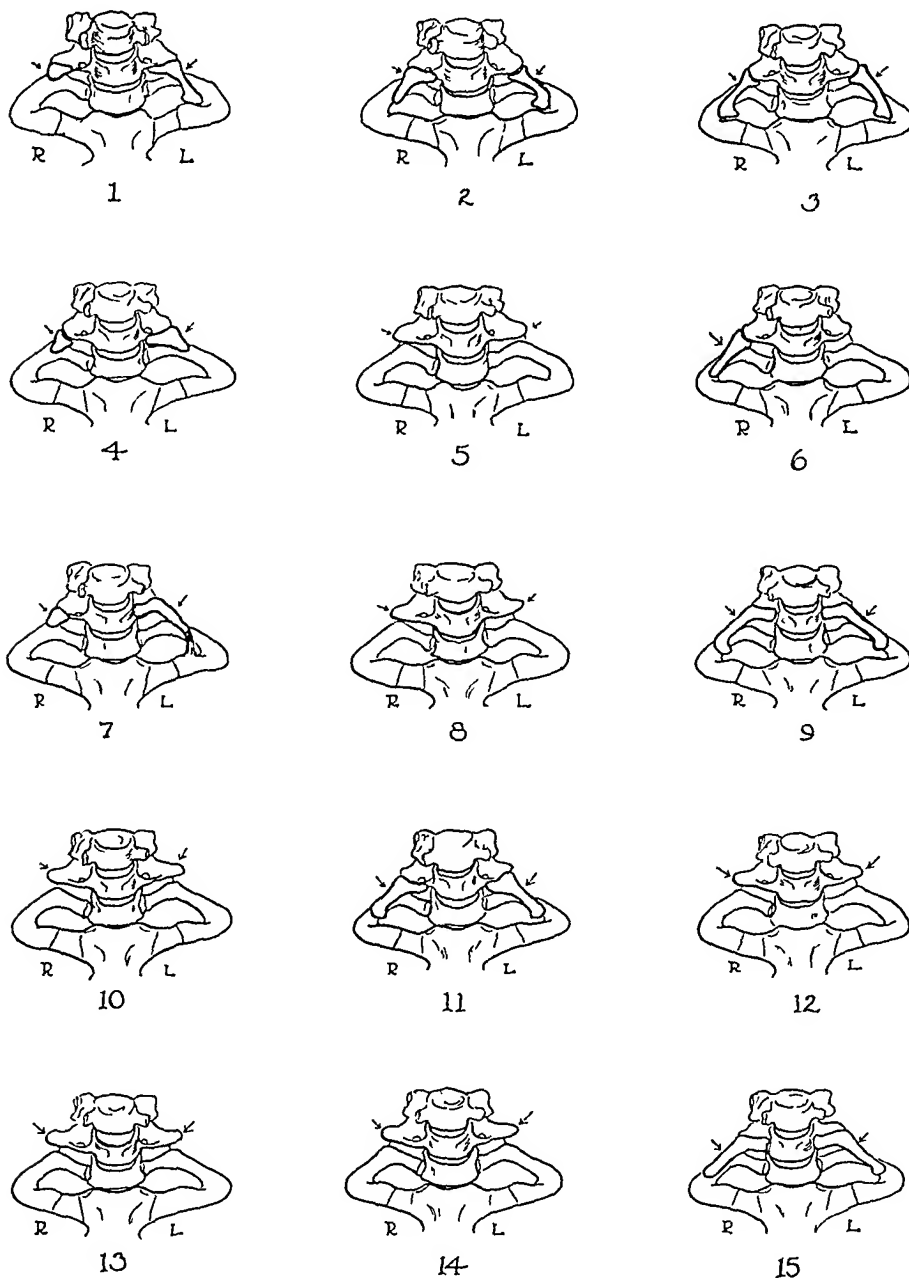


PLATE II—Drawings from roentgenograms of 15 actual cases. Most all possibilities are found. Enlarged transverse processes, bilateral ribs of the floating type or articulating with the first rib, single ribs either floating or articulating, and rudimentary rib tips. Nos 5, 8, 10, 12, 13 and 14 had anterior scalenus symptoms. Nos 5, 8 and 14 were operated upon with relief of symptoms.

lateral ribs of the floating type, or bilateral ribs articulating with the first rib (3) Unilateral ribs, either floating or articulating with the first rib (4) Rudimentary rib tips, either single or bilateral. One case (Plate III, Fig 20)

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showed rudimentary rib tips at the sixth cervical vertebra and fully developed ribs from the seventh cervical vertebra. The cases with a single rib, with or without a rudimentary tip on the opposite side, were three times more

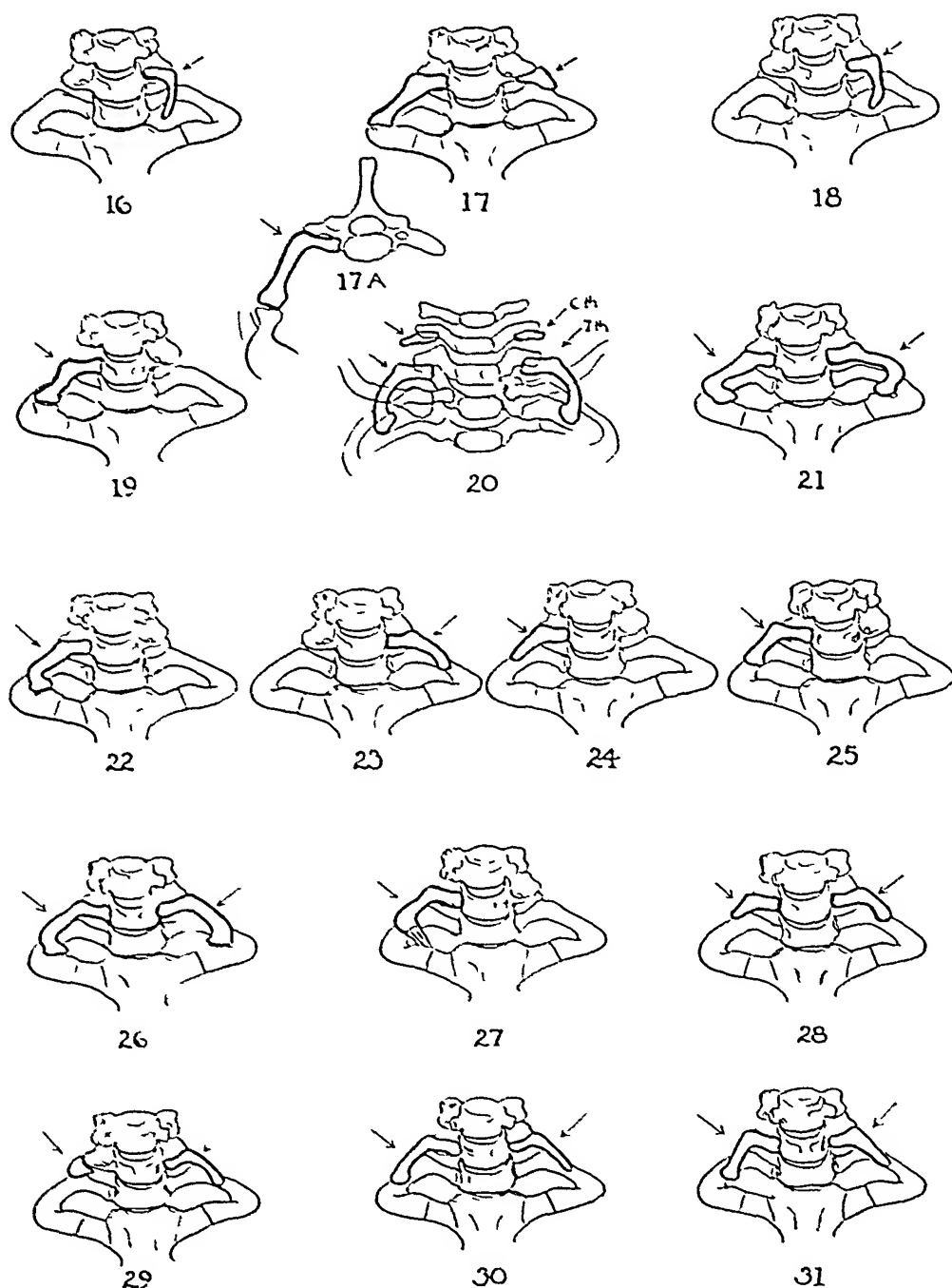


PLATE III—Drawings from the roentgenograms of 16 more actual cases. Number 20 is unique in that there were rudimentary sixth cervical rib tips and well developed seventh cervical ribs. This case was a full term stillbirth.

frequent than the cases with bilateral ribs. The cases with enlarged transverse processes and those with bilateral ribs were about equal in number.

Sixteen of the 31 cases had symptoms. The symptoms were always related to pressure or irritation of some part of the brachial plexus or subclavian artery. Although the lower nerves of the brachial plexus were more

commonly involved, all of the components of the plexus were in one case or another affected. Sometimes the symptoms were at the base of the neck, again they were about the entire shoulder, or the upper arm, or the lower arm, or the hand, or any combination of these. The patients' complaints, in their relative frequency, were as follows: Pain of varying intensity, tiredness and weakness of the extremity, cramps in the fingers, numbness, tingling or coldness of the hand, areas of hyperesthesia, shrinking of some of the muscles of the hand, a lump at the base of the neck, tremor of the fingers, discoloration of the fingers. The symptoms were increased from month to month. They grew worse with the day's progress. Work and exercise accentuated the symptoms. All of the symptoms were in part relieved by elevation of the upper extremity and by rest.

The cases with symptoms will be considered in two groups, ten with cervical ribs, and six with enlarged transverse processes and belonging to the so-called scalenus syndrome group.

Of the ten cases, three had symptoms on the right side, six on the left side, and one case had symptoms on both sides. In every case the symptoms were on the side where the cervical rib was the larger. Two cases were male and eight were female. All the cases were between the ages of 20 and 31.

Seven of the ten rib cases with symptoms were operated upon. The same operation was performed in each instance. The skin incision was made at the base of the neck, bisecting the angle formed between the sternomastoid muscle and the clavicle. The phrenic nerve was isolated, the subclavian artery was identified, the scalenus anticus muscle was divided, the brachial plexus was identified, the scalenus medius muscle was divided at its upper portion. The cervical rib was rongeuried away in small bits and the wound was closed in layers. A few points to be emphasized in surgical technic are as follows. As described in a previous communication,⁵ we still use the lower half of the scalenus medius muscle as a tractor against the brachial plexus. We again want to emphasize the fact that retraction or even moderate pulling on the brachial plexus will produce symptoms for months after the operation. Secondly, we wish to advise that the scalenus anticus muscle be divided one to two inches or more above its first rib attachment, because of the fact that the pleura so frequently comes up behind this muscle and sometimes a full inch above the first rib (Fig. 2). It should be noted that with an extra rib we have one more intercostal space with a probable enlarged pleural cavity. We have seen the pleura nicked or opened on two occasions. In each instance the opening was quickly covered with moist cotton and later on by a good piece of muscle. No harm resulted. The "fibrous band," often spoken of, has been found in two of our cases (Plate II, Fig. 7, and Plate III, Fig. 23). In one instance, the band extended from the tip of the rudimentary rib downward and along and continuous with the sheath of the scalenus medius muscle. In the other instance of the "fibrous band," the latter extended from the tip of the rib over to the scalene (Lisfranc's) tubercle. We believe in dividing the anterior scalenus, and the middle scalenus muscle, and in rongeuried most

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of the cervical rib away whenever it is present. Of the seven operated cases, six are now symptom-free.

There were six cases with anterior scalenus syndrome. All were females. Three had symptoms on the left side and three on the right side. All of the patients were between the ages of 20 and 30 except one woman, who was 40.

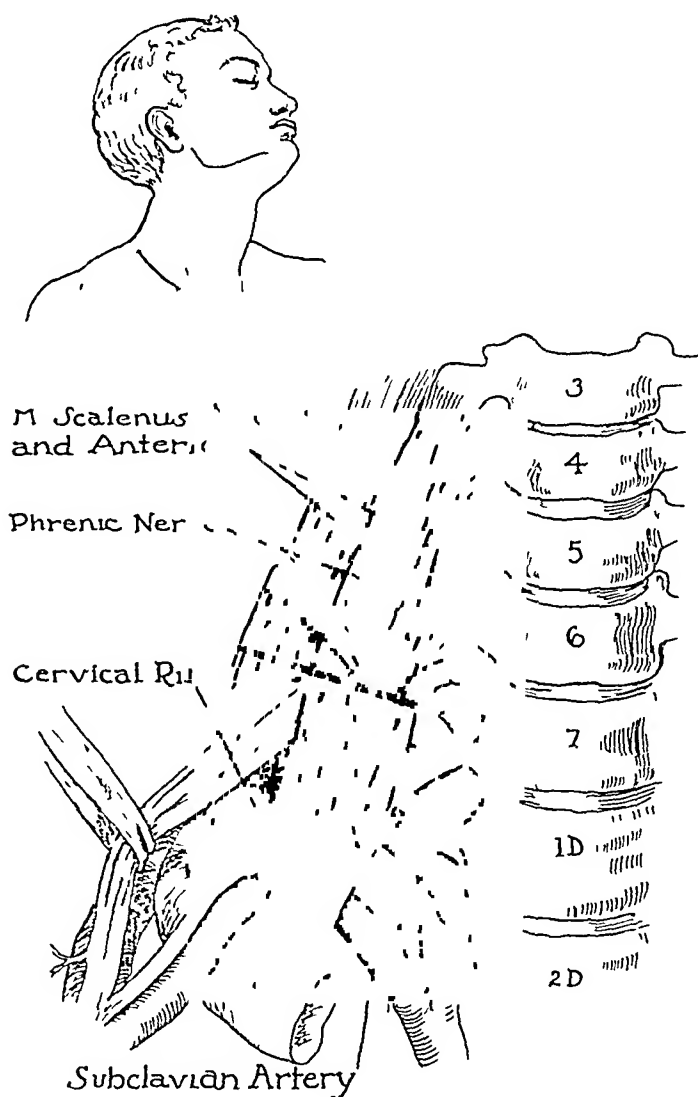


FIG. 2.—The transverse black line is the level at which we suggest division of the scalenus muscles. There will be less danger of injuring the pleura which is often one space higher in cervical rib cases. The insert shows the line of the skin incision which bisects the angle formed by the sternocleidomastoid muscle and the clavicle. (Redrawn from A. W. Adson⁸ and W. C. Carroll¹².)

Three of the six cases were operated upon. The operative incision was the same as that employed for the cervical ribs, the anterior scalenus merely being divided. The scalenus muscle in each instance was enormously hypertrophied, being three or four times its normal size in two of the cases. Of the three cases not operated upon, the symptoms were not severe enough to warrant operative interference.

Even with a well-developed cervical rib, a correct diagnosis is frequently very difficult to make, and without the cervical rib, the statement is even more

true There are cases, although they are very rare, where serious interference with the circulation is evidenced In such cases a diagnosis, as quickly as possible, followed by operation, is indicated In all of the rest of the cases, if a careful study is not made, useless operations may result It may be of interest to briefly cite the following cases

ABBREVIATED CASE REPORTS

Case 1—The patient, a female, age 35, complaining of soreness in the right shoulder, right side of the neck and pain radiating down the lateral aspect of the whole right arm, was found to have a back strain associated with spina bifida occulta of the seventh cervical and the first dorsal vertebrae (Fig 3)



FIG 3—Case of seventh cervical spina bifida with symptoms at first thought to be due to the scapular syndrome

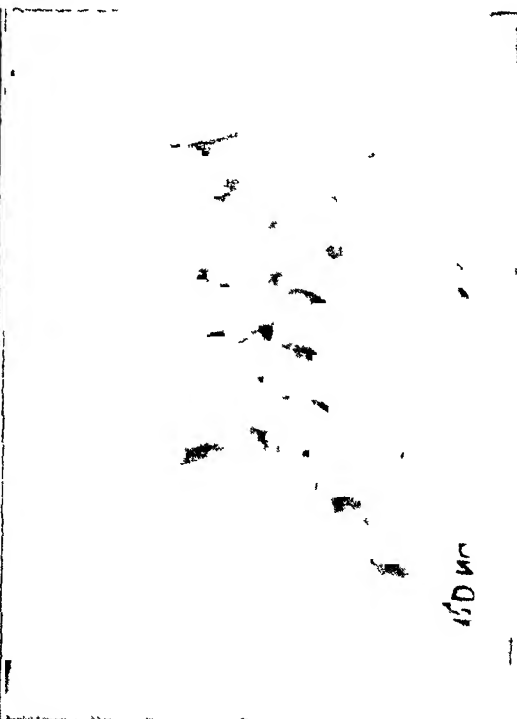


FIG 4—Arthritis of the fifth and sixth cervical vertebrae producing symptoms very similar to cervical rib Note the absence of the normal anterior neck curve the diminution in the space between the affected vertebrae, and the narrowing and locking present

Case 2—The patient, a female, age 30 complained of cervicodorsal pains after working for long hours, pain in the right shoulder after sitting in one position for a long time, and she felt a bony mass in the right supraclavicular region This patient was found to have an enlarged seventh cervical transverse process, spina bifida with structural defects of the laminae of the first dorsal vertebra, and a congenital deformity of the scapula

Case 3—The patient, a female, age 27, four feet nine inches tall, complained of numbness in both arms, especially the right, which was more marked at night after typing Roentgenologic examination showed marked arthritis between the fifth and sixth cervical vertebrae with marked hypertrophic changes in the adjacent surfaces of the vertebral bodies (Fig 4)

Case 4—The patient, a male, age 40, complained of "pins and needles" from the right elbow to the ends of his fingers When he tipped his head back, the symptoms were

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increased. His little finger and half of his ring finger felt cold most of the time. Examination showed him to have an old anterior subluxation of the right shoulder with pressure on the brachial plexus.

Case 5—The patient, a female, age 29, known to have rheumatic heart disease complained of pain in the left side of the neck, over the left shoulder, along the lateral aspect of the left arm, and the dorsum of the hand. Roentgenologic examination showed her to have very large transverse processes of the seventh cervical vertebra. It was not thought that the symptoms were the result of her cardiac condition. She was observed over a period of one year during which time her symptoms disappeared.

Case 6—The patient, a male, age 24, complained of pain at the base of the left side of his neck and the muscles of the superior and lateral aspects of the shoulder. Roentgenologic examination of the cervical spine showed a questionable tuberculous lesion and

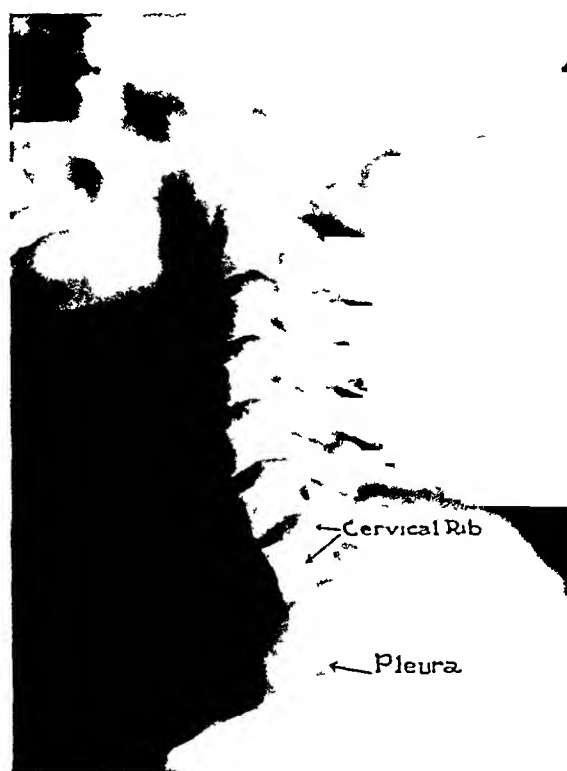


FIG 5—This is Case 1 of Plate II in the lateral view showing the cervical rib as a faintly white exclamation point shadow lying obliquely across the seventh cervical vertebra. The pleura is seen as an oblong shaded area in front of the base of the neck.

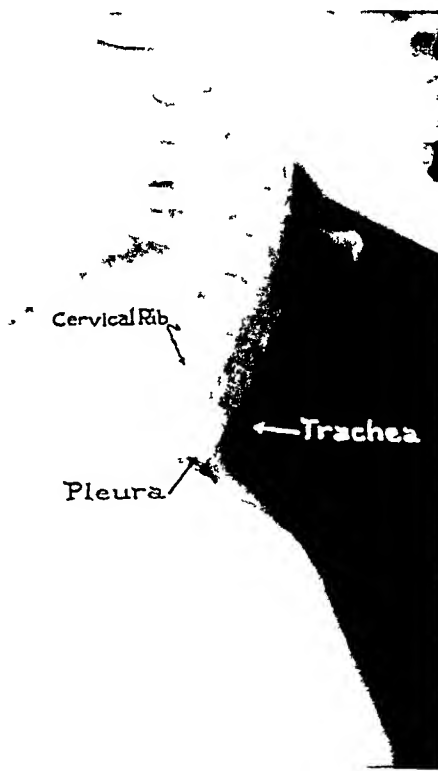


FIG 6—This is the lateral view of Case 4 of Plate I. The cervical rib is seen, the trachea and pleural dome are clearly shown. At operation the pleura is in constant danger of injury.

treatment, predicated upon such a diagnosis, was being considered when further roentgenograms, taken elsewhere, showed a cervical rib, which was found to be responsible for the symptoms.

Case 7—The patient, a female, age 29, developed pain in the left shoulder, particularly in the scapular region. She was referred for roentgenologic examination of the teeth and chest, and her cervical spine was not shown in the films. Physiotherapy treatment for subdeltoid bursitis was advised. The symptoms increased and extended down the lateral aspect of the shoulder, upper and lower arm, and marked tremor developed in the left hand. She was operated upon elsewhere, at which time a typical, rudimentary seventh cervical rib was found on the left side, removal of which relieved her of all symptoms.

Any vascular disease, such as Raynaud's disease or thrombo-angitis obliterans, may produce symptoms of cervical ribs. Ray⁶ has recently re-

ported a group of cases of tumors of the "apex of the chest" Symptoms from these are at times not unlike those from cervical ribs Reid⁷ reported a few cases of cervical rib with symptoms very closely simulating those of angina pectoris or coronary thrombosis, and he called attention to the fact that such patients were likely to be referred to the Cardiac Clinic

In addition to the ordinary roentgenograms taken, we want to mention a few observations not commonly described (1) In the lateral view, the cervical rib will frequently be shown as an oblique, faintly white streak running downward across the body of the seventh cervical vertebra This streak sometimes looks like the outline of a calcified tadpole (Fig 5) (2) Also, in the lateral view of a patient with a long neck, a dark, oblong shadow may frequently be seen in front of the lower cervical vertebrae The center of this shadow lies between the lower cervical vertebrae and the trachea (Fig 6) This represents the pleural cavity or lung, and only emphasizes the suggested technic of dividing the anterior scalenus muscle higher than is generally advised (3) As previously suggested by us,⁵ a cervical rib is sometimes best demonstrated by placing the patient in an oblique position and having him take a swallow of a barium meal The rib will be seen at the top of the column of barium passing through the esophagus

DISCUSSION—Recently, the impression has become rather general that in all cases of cervical ribs, symptoms can be entirely relieved by a simple division of the anterior scalenus muscle The largest number of cases so treated has been reported in several papers from the Mayo Clinic⁸ But in the summary of one of the papers, Craig and Knepper⁹ make the following statement "In the presence of a cervical rib without tendinous attachments and without obvious pressure from behind, resection of the scalenus anticus muscle is all that is necessary, but when there is evident pressure from the cervical rib or its tendinous attachment, resection of the rib and the attachment should be carried out" With this statement there can be very little argument

Cases of anterior scalenus syndrome now greatly outnumber those with cervical ribs, and the symptoms of the two are very similar Since division of the scalenus muscle so frequently relieves both conditions, there is a tendency to regard that procedure as sufficient in all cases If the surgeon elects, simple division of the anterior scalenus muscle may be first tried If the symptoms are not relieved, the cervical rib may be removed at a later operation We have found that it is technically not difficult to carry out both procedures at one operation If one is not experienced in neck surgery, the simple muscle division, of course, would be the better Removal of the cervical rib requires a longer incision and it takes about twice the length of time as the simple muscle division We have not noted any deaths resulting from the rib operation In cases of impending gangrene of the fingers, or serious vascular symptoms, I would advise removing the cervical rib, if one were present

There is evidence to prove that long continued pressure of the cervical

rib on the brachial plexus brings about a chronic aseptic inflammatory reaction which if continued long enough may bring about a permanent fibrosis¹⁰ Such a fibrosis may account for the failure to relieve symptoms following even the more extensive operation for cervical ribs. I have had one such case, in which the anterior and middle scalenus muscles were divided and the rib was removed. This patient was reported as Case 2 in a previous article.⁵ Her symptoms apparently cleared up a few months following the operation but very soon recurred. She was seen recently and her arm still bothered her. Of course at operation we may have traumatized the brachial plexus.

Whereas in the first part of this present communication we dealt with developmental facts as to why cervical ribs are formed and why they give symptoms still there is no question that there are many times other contributory factors. Trauma either on one occasion or continued over a period of time plays an important rôle. Anatomic variations are at times most important as (1) First ribs which are unusually high, very large or irregularly curved. (2) The anterior scalene tubercle may be greatly enlarged. (3) The brachial plexus may come off one segment higher or lower, and it may vary in its branching combinations. (4) The right subclavian artery may even come directly off the aortic arch¹⁸ the artery or the vein may pass in front of, behind or through the anterior scalenus muscle. (5) Bony deformities of the chest may broaden or shorten the lateral diameter of the entrance to the thoracic cage. (6) Curvatures of the spine may bring about an unusual pull on the first rib or the cervical rib. (7) It is generally thought that with advancing years the shoulder girdle descends and thus further angulates the brachial plexus and the subclavian vessels as they pass over the first rib.

In 1916 Halsted¹¹ reported 716 cases of cervical ribs recorded in the literature to that time. Halsted was especially interested in aneurysms or dilatations associated with cervical ribs, and he found 27 such instances. Adson⁸ states he has never seen an aneurysm associated with cervical ribs. We have seen arteries compressed either by the rib or the scalenus muscle and immediately following the operation, have seen rather dramatic restoration of the artery to its normal size. There have been cervical rib cases with aneurysms and syphilis.¹⁴ There is, of course, a certain percentage of people without cervical ribs who develop subclavian aneurysms. There have been only a few cases of complete obliteration of the subclavian artery. One such case was reported by Oljemick,¹³ in Cushing's Birthday Volume, one by Lindskog and Howes,¹⁴ and one by us⁵ in 1935. Due to its unusual subsequent course, our case is reported somewhat in detail.

Case Report—A M., female, age 31, had bilateral cervical ribs articulating with the first ribs. For six months she had had symptoms on the left side, consisting of coldness of the extremity and weakness in the hand and arm. There was no pulse palpable in the extremity, and at operation the subclavian artery was found to consist of a fibrous, avascular cord. The anterior and middle scalenus muscles were divided, the cervical rib was rongeué away, and the patient made an uneventful recovery. Her symptoms disappeared but she has never had a palpable pulse in that extremity since.

On May 13, 1938, three years after the first operation, the patient returned because she had for several months been noticing increasing numbness of the right upper extremity and, in particular, the fingers of the right hand. Her symptoms were more marked when she tried to bend over.

Physical Examination—Blood pressure in her right arm was 110/60, whereas, in her lower extremities the blood pressure was 142/80. Since her symptoms were increasing, since she had previously lost the main artery to her left upper extremity, operation was urged and was performed three days later.

Operation—The subclavian artery was compressed forward against the anterior scalenus muscle by a large cervical rib which articulated with a large scalene tubercle. The artery appeared to be bent over the cervical rib. The anterior scalenus muscle was divided two inches above its insertion. The artery was still narrowed and the cervical rib still pressed upon it. The rib was then rongeured away. The artery then fell back into the space occupied by the rib. It was remarked that the subclavian artery was 40 per cent larger at the end of the operation than at the beginning. The brachial plexus, as was the case on the left side, was postfixed in type. The cervical rib passed through the middle of the plexus. Following operation the patient's symptoms were immediately relieved and she has remained symptom-free.

Circulatory disturbances are now regarded as due to a constant stimulation of the sympathetic (constrictor) nerve fibers of the artery to the extremity,^{10, 15} or else there is direct pressure or angulation of the vessel. In any event, the pathologic process is supposed to take place over a long period of time and, from other observations in vascular surgery, one would think it much better to bring about a gradual diminution in size of the artery, thus giving collateral circulation a chance to fully establish itself. Quite contrary to this idea, and very practical to know, is the manner in which some surgeons have dealt with aneurysms associated with cervical ribs. In addition to the rib operation at least in one instance,¹⁶ the aneurysm was doubly ligated *in situ*, and on another occasion¹⁷ the aneurysm was removed by immediate double ligation. In both instances there was a good postoperative recovery.

CONCLUSIONS

(1) The occurrence of and the symptoms from cervical ribs are explained on the basis of comparative anatomy and embryology.

(2) During inspiration the scalenus muscles may cause pressure or accentuate rib pressure on the brachial plexus and the subclavian vessels.

(3) Anatomically, cervical ribs may be divided into four broad groups. Those with enlarged transverse processes, bilateral ribs, either floating or articulating, unilateral ribs, either floating or articulating, rudimentary rib tips, either single or bilateral.

(4) The chief complaint of the patient is pain of varying intensity. The pain may be in any part of the neck, shoulder or the upper extremity.

(5) At operation we advise division of the anterior and medial scalenus muscles and removal of the rib, if present. We also suggest division of the anterior scalenus through the muscle belly so as to avoid the pleura.

(6) The dome of the pleura is probably higher in the neck of people with cervical ribs.

(7) In the differential diagnosis, even if a cervical rib is present, the following conditions should be excluded: Arthritis of the spine or shoulder, bursitis, apical tumors, neuritis, vascular diseases, congenital deformities, and cardiac diseases.

(8) Lateral roentgenograms will frequently show the cervical rib running diagonally across the body of the seventh cervical vertebra, they will also show the pleura at the base of the neck in front of the spine.

(9) Aneurysms of the subclavian artery caused by cervical ribs or anterior scalenus syndrome are very rare. The aneurysm, if present, may be doubly ligated and resected, or not, with safety.

(10) Circulatory disturbances are probably due to repeated stimulation of the vasoconstrictor nerves, or to direct pressure on, or angulation of, the subclavian vessels.

REFERENCES

- ¹Walter, H. E. *Biology of the Vertebrates*. The Macmillan Co., 1929.
- ²Kingsley, J. S. *Comparative Anatomy of Vertebrates*. P. Blakiston's Son and Co., 1912.
- ³Lewis. *Gray's Anatomy*. 21st Ed., p. 124.
- ⁴*Ibid*, p. 409.
- ⁵Patterson, R. H. *Surgery for Cervical Ribs*. *ANNALS OF SURGERY*, 102, 972, 1935.
- ⁶Ray, B. S. *Tumors at the Apex of the Chest*. *Surg., Gynec. and Obstet.*, 67, 577, 1938.
- ⁷Reid, W. D. *Pressure on the Brachial Plexus Causing Simulation of Coronary Disease*. *J. A. M. A.*, 110, 1724, 1938.
- ⁸Adson, A. W. *Surgical Treatment of Cervical Ribs*. *Texas State Jour. Med.*, 28, 739, 1933.
- ⁹Craig, W. McK., and Knepper, P. A. *Cervical Rib and the Scalenus Anticus Syndrome*. *ANNALS OF SURGERY*, 105, 556, 1937.
- ¹⁰Blair, D. M., Davies, F., and McKissock, W. *The Etiology of the Vascular Symptoms of Cervical Rib*. *Brit. Jour. Surg.*, 87, 406, 1935.
- ¹¹Halsted, W. S. *Surgical Papers*. Johns Hopkins Press, 445-449, 1924.
- ¹²Carroll, W. C. *Cervical Ribs and Abnormal First Thoracic Rib*. *Minnesota Med.*, 15, 828, December, 1932.
- ¹³Oljenick, Ignaz. *Bilateral Cervical Rib*. *Arch. Surg.*, 18, 1984, 1929.
- ¹⁴Lindskog, G. E., and Howes, E. L. *Cervical Rib Associated with Aneurysm of the Subclavian Artery*. *Arch. Surg.*, 34, 310, 1937.
- ¹⁵Telford, E. D., and Stopford, J. S. *Brit. Jour. Surg.*, 28, 557, 1931.
- ¹⁶Moore, C. A. *A Case of Subclavian Aneurysm with Cervical Ribs*. *Lancet*, 1, 1045, 1922.
- ¹⁷Billington, W. *Excision of Subclavian Aneurysm Associated with Cervical Rib*. *Brit. Jour. Surg.*, 19, 334, 1931.
- ¹⁸Dolgopol, V. B. *Anomalous Origin of the Right Subclavian Artery from the Descending Arch of Aorta*. *Jour. Tech. Meth. and Bull. Internat. Assoc. Med. Mus.*, 13, 112, 1934.

DISCUSSION—DR WILLIAM DEW ANDRUS (New York) said that the difficulty in differential diagnosis of both cervical rib and the scalene muscle syndrome is evident. Doctor Smith's case illustrated the widespread symptoms that may occur from another type of abnormality in this region and Doctor Patterson brought out in connection with two cases that other lesions may give rise to symptoms similar to those caused by cervical ribs. In the

New York Hospital, during the last few years, there have been seven cases of cervical rib or scalene syndrome. Five had cervical ribs—three were complete articulating ribs and two were with a fibrous band. Two cases were of the so-called scalene syndrome. One patient was a woman, age 52, who complained that she woke up every morning with a swollen left hand and cyanosis of the finger tips. On further inquiry it developed that she always slept on the left side and used a high pillow. She would turn on the right side for relief. She was observed for several days and, as roentgenograms showed no evidence of cervical rib, a diagnosis of scalene anticus syndrome was made. She was completely relieved following the section of the muscle.

So many anatomic abnormalities can occur in this region that it is difficult to implicate any single one. Emphasis has been placed on hypertrophy of the scalene anticus muscle as being of considerable importance, more so perhaps than the alleged inflammation supposed to occur according to some of the earlier reports. The reason for the hypertrophy, however, remains obscure in many cases. It can be explained in some instances by a more than usually vertical position of the first rib, in which case the angle at which the scalene muscle acts to elevate the rib is more acute, thus requiring more force to raise it, and also making the angle through which vein and artery must pass more acute and accentuating the pressure exerted upon them.

DR BEVERLY CHEW SMITH (New York) said that the presence of cervical rib should be suspected in all cases of neural or vascular symptoms in any upper extremity. Whereas the actual presence of a rib can be revealed by roentgenologic examination and, in some cases, by palpation, quite often symptoms associated with actual cervical rib persist in the absence of a demonstrable rib. This later condition is recognized to-day as the scalene anticus syndrome and is associated with a tense deep cervical fascia posterior to the scalene anticus, an hypertrophied muscle or a band from a transverse process to the first rib. The relief of symptoms following the division of the scalene anticus in these cases has been so brilliant that it has led to the assumption that muscle division alone will relieve symptoms in the presence of actual cervical ribs. This is not wholly true, as in those cases where the ribs are sufficiently large and the plexus is more caudally fixed, excision of the rib is required to give permanent relief. Doctor Patterson stresses in his technique the value of the scalene medius as a tractor after its division in protecting the plexus during extirpation of the rib. This point should be borne in mind if rib resection is necessary. The multiplicity of vague symptoms from vascular spasm, intermittent claudication, arterial subclavian occlusion, gangrene of digits, cardiac palpitation, nausea and faintness, makes cervical ribs and associated scalene anticus syndrome a major surgical diagnostic problem.

Doctor Smith said he believed it expedient in all operations for cervical rib or scalene anticus syndrome to divide the fascia posterior to the scalene anticus after division of the muscle, for not until this is done will the plexus or subclavian artery be freed of the pressure upon them anteriorly.

Diagnostic exploration of the scalene region is indicated in cases of this syndrome in the absence of roentgenographic evidence of cervical ribs, if symptoms are progressive, unrelieved by palliative treatment, or are exaggerated by position associated with increasing symptoms in the presence of actual cervical ribs.

DR JOHN M. HANFORD (New York) There are a great many phases of this subject which one might discuss. I would like to speak first about conservative treatment. It seems to me that occasionally there may be justifica-

tion for tying this. The main indication, I would say, would be the absence of organic disease—that is, symptoms without evidence of organic disease. Dr. Walter M. Buckner, twelve years ago, gave a very interesting discussion of pressure upon the brachial plexus and upon the artery by a normal first rib, and recommended conservative treatment in certain types of cases by rest, by elevation of the arms and by such exercises as might facilitate the release of the pressure of the first rib. One might consider that treatment (especially in patients who might not be suitable for operation), if they have no organic disease or no definite evidence of damage to the circulation or nerves.

Another phase of this subject which interests me very much is the mechanism which causes the symptoms. It is easy enough to explain symptoms due to pressure upon any nerve or nerve root, but why does constriction of the subclavian artery cause symptoms even before thrombosis and actual occlusion have occurred? In some of these cases, like Doctor MacFee's, there was no apparent thrombosis or damage to the artery. There was only narrowing and a slight aneurysmal dilatation, but why was the patient having symptoms? I understand that the patient had no damage to the brachial plexus of any consequence. The subclavian artery can be ligated immediately, distal to the thyrocervical trunk, without any such symptoms. Then how do these symptoms develop? I do not know. I would like to be enlightened. It probably is known. At least there may be very good theories. But it seems to me that it must be related to the innervation of the artery, which may have something to do with the studies which Leriche made in the periaxillary sympathectomies. A patient of mine, like Doctor Smith's, had thrombosis of the distal part of the subclavian artery, the artery gave no pulsation down the limb, and presented all the evidences of arterial occlusion, yet release of the artery at operation relieved her symptoms. Two months ago when I saw her (seven months after operation) she was still enthusiastic about the results of the operation which consisted of nothing but release of the artery. She had no evidence of nerve damage. How was she benefited and what mechanism caused her symptoms? That is a very interesting pathologico-physiologic study. This patient I operated upon had a thrombosis. I opened the artery, passed a probe down the axillary artery, which was completely thrombosed, and examination of the clot showed organization. Nothing was done to improve the arterial circulation. She had a cervical rib which I did not touch. She improved. Why?

Another phase of the subject is the technic. My impression is that division of the sternomastoid along the clavicle is helpful in obtaining good exposure. Very careful hemostasis is important. Division of the omohyoid is justifiable. Division of the scalenus anterior may not succeed if it is made high because in my patient just referred to, there was dense tissue along the lower part of the muscle, and I had to divide this low down in order to release the artery. In working about the lower part of the muscle, certainly one should be careful about the pleura. The stress laid upon care in the traction upon the brachial plexus by Doctor Patterson is most important. Nerves do not withstand traction! If ever there was a sound surgical axiom, that is one. The scheme of retracting the plexus very gently is most important.

DR. RUSSEL H. PATTERSON (closing) said that in every case the symptoms were on the side where the rib was largest. He agreed with Doctor Smith about cutting the muscle and fascia, and said that this principle was certainly true in two of his cases. If the fascia had not been cut either in front or behind the scalenus anterior or the scalenus medius, the first rib would not have been released.

THROMBOSIS OF THIRD PORTION OF SUBCLAVIAN ARTERY ASSOCIATED WITH SCALENUS ANTICUS SYNDROME*

BEVERLY CHEW SMITH, M D

NEW YORK, N Y

Case Report—E H, male, age 28, was first admitted to Vanderbilt Clinic, September 1, 1937, complaining of palpitation of the heart of six months' duration. His past history was negative. His personal history was also negative, except that he consumed one and a half packs of cigarettes and seven cups of coffee a day. He enjoyed excellent health until September, 1935, at which time he first noticed palpitation, precordial pain accelerated by exertion, and nocturia of two to three times. During the first six weeks of this complaint he lost 18 pounds, became worried and introspective. Following palpitation he noted hot flashes, dripping night sweats, polydipsia and polyuria seven to eight times daily. His doctor told him that he had high blood pressure but did not tell him the readings. Without treatment his symptoms disappeared slowly in two months. He remained symptom-free for one and a half years except for short attacks of palpitation which recurred irregularly for a month. Six weeks before admission, his symptoms reappeared and gradually increased in intensity and frequency. The cervical nodes on both sides of his neck would swell and recede for a period of two to three hours during the day. They were not painful, but were uncomfortable. He noticed increased nervousness and irritability.

From September 1, 1937, to June 27, 1938, he was seen a number of times in various departments of Vanderbilt Clinic, where his blood pressure varied from 190/100 to 140/85. His urine was negative. The Wassermann was negative. At odd times he complained of consciousness of his heart when lying on his left side at night because of its forceful beat. He was considered a case of neurocirculatory asthenia. He became worried about himself which accelerated his symptoms. In May, 1938, pain occurred in his left shoulder radiating down to his left elbow, and at this time it was noted that, although the right radial was normally palpable, the left radial could barely be felt. The right brachial blood pressure was 165/95, the left 115/85. On May 31, 1939, roentgenogram No 172740 was negative for cervical ribs. Transverse processes of the seventh cervical vertebra were said to be a little longer than normal.

June 6, 1935. Oscillometric readings, at 130 Mm Hg pressure showed

	Right	Left
Lower $\frac{1}{3}$ arm	9	2
Midforearm	5	1
Upper $\frac{1}{3}$ leg	7	7

He began having intermittent claudication of his left hand and arm, to such an extent that he frequently had to rest during his work as a soda dispenser and could not work longer than four hours at a stretch without a long rest period. His symptoms became more pronounced and he noticed transient weakness in his left upper extremity associated with tremor and sweating limited to face, neck and arms. His left arm was weaker, colder and bluer than the right.

Physical Examination—This was essentially negative except that the left radial and brachial pulse could barely be appreciated, and left subclavian above the clavicle could not be felt. The left nail beds were slightly cyanotic. The ulnar, radial and biceps

* Presented before the New York Surgical Society, April 26, 1939. Submitted for publication July 7, 1939.

SCALENUS ANTICUS SYNDROME

reflexes were less active on the left than on the right side, and there was atrophy of the left thenar eminence

In June, 1938, his left arm frequently became numb and his capacity for using it limited its use to such an extent that he could not carry a newspaper or magazine in his hand. It became painful and felt as if it were asleep. He was breathless after climbing two flights of steps. He became conscious of holding his head bent to the right which caused his left shoulder to be higher than the right.

Blood pressure readings were as follows

	Right	Left
Sitting with arm at side	165/100	115/80
Sitting with arm abducted	150/100	100/80
Sitting with arm overhead	130/50	85/75

Surface temperature in both hands and forearms was normal at 31.5° C

Examination by the Neurologic Department revealed no disease of the spinal cord, nerves or brain

An electrocardiogram (No 50958) June 22, 1938, was normal

Oscillometric Readings	Right	Left
Arms at side—midforearm	4 5	2
lower third of arm	9	3
Arms extended—forearm	5	1
arm	6	0 5
Abducted 90°—forearm	4	1
arm	6 5	2
Elevated to 180°—forearm	3	0
arm	4	0

Eye examination by the Ophthalmologic Department was negative. A six-meter roentgenogram of heart showed no cardiac enlargement. Red blood count 5,000,000, white blood count 11,450, polys 72 per cent.

Operation—June 24, 1938. Under avertin-nitrous oxide-ether anesthesia, a left lateral, low collar incision was deepened through the platysma and the clavicular portion of the sternomastoid muscle, and the phrenic nerve was retracted from the anterior surface of the scalenus anticus muscle. The scalenus anticus muscle was then divided near its insertion on the first rib. The subclavian artery was exposed with the thyro- and costocervical trunks. Good pulsations were noted in both thyro- and costocervical trunk at the third part of the subclavian artery. No pulsations were felt in the subclavian distal to this point but normal pulsations proximal to this trunk were noted.

A hypodermic needle inserted into the subclavian proximal to the costocervical trunk yielded blood, lateral to this trunk no blood was obtained. The transverse scapular artery was dilated. The lateral edge of the cervical fascia posterior to the scalenus anticus muscle was a taut, hypertrophied fascial band which partially compressed the subclavian artery just distal to the costocervical trunk, where the medial edge of the thrombosed subclavian was noted. There was no pulsation in the third portion of the subclavian or the radial when this band was released.

His postoperative course was uneventful. He was discharged on the eighth post-operative day. His wound healed per primam.

Subsequent Course—Follow-up at three months. The patient reported that his left arm was stronger although it still tired more quickly than the right, left forearm still remained smaller than the right. There was no coldness, cyanosis or tingling of his hand, his grasp was normal but there was no change in the thenar atrophy. The Cardiology Clinic reported a normal heart.

Follow-up at five months—November 15, 1938. Left radial was found to be slightly

more palpable, both brachials were palpable but could be felt on the right much stronger than on the left. The entire left upper extremity felt much more normal. His hand did not tingle as previously. His palpitation, nocturia, polyuria and sweating had disappeared. Cold weather did not bother him as it had previously. Oscillometric readings were the same.

At ten months after operation, his left upper extremity was symptomless. He had no pain, did not become fatigued, and worked nine hours daily as a soda dispenser without intermittent claudication of his left upper extremity. He had no cardiac or chest symptoms, he was less nervous, his hand was pink, and his arm felt normal.

BP right 160/90—left 110/80. The right radial, brachial, axillary and subclavian arteries were normally palpable, but on the left side they were felt with great difficulty and at times the pulse was imperceptible. With both hands above his head the left was paler than the right but both pinked normally when dependent.

Oscillometric Readings	Right	Left	Pulse 92
	120	100	
Lower $\frac{1}{3}$ arm	9 0	2 5	
	120	100	
Midforearm	5 5	2 0	

The patient is shown as a case of scalenus anticus muscle syndrome with symptoms simulating coronary disease, without a cervical rib but with the thickened lateral edge of the cervical fascia posterior and lateral to the scalenus anticus muscle pressing on the third portion of the subclavian artery resulting in a thrombosis which had become an organized fibrous cord. Division of the fascia, where it compressed the artery, relieved all of his cardiac symptoms, the pain in his shoulder and arm, and the intermittent claudication while at work as a soda dispenser. There was no evidence at operation of compression of the nerves of the brachial trunk.

CERVICAL RIB CAUSING PARTIAL OCCLUSION AND ANEURYSM OF THE SUBCLAVIAN ARTERY¹

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NEW YORK, N. Y.

CERVICAL RIB is usually a bilateral condition, and the practical effect, as Keen¹ has observed, is to lengthen the chest by one rib. The upward displacement of structures depends upon the extent of development of the anomalous rib and the nature of its fibrous attachments at the anterior end. The brachial plexus usually passes over the rib and symptoms frequently arise from pressure, particularly upon its lower cord. If the rib is short the arch of the subclavian artery may not be disturbed, but if the rib is long the artery may be carried over it or be caught and compressed between the anterior end of the rib and the tendinous insertion of the anterior scalene muscle. The symptoms in the latter case are primarily referable to the arterial occlusion which is usually incomplete. Because of its lateral and posterior position the brachial plexus suffers interference much more frequently than the subclavian artery.

Case Report—Hosp. No. A-04447. A. L., white, male, age 28, was admitted to St. Luke's Hospital, July 9, 1938, complaining of severe, steady pain in the fingers of the left hand, particularly the first, second, and third fingers, and a progressive sore on the end of the third finger of the left hand.

He stated that in December, 1937, approximately seven months before admission, while working out of doors, his hands became so cold that he was obliged to stop work. He soaked them in cold water and worked them until the circulation returned. With the return of circulation, there was a burning sensation which affected chiefly the left hand.

About two weeks later the patient accidentally inflicted a superficial scratch on the end of the left middle finger with a screw driver. This slight wound did not heal, but instead became surrounded by an area of redness and swelling. The lesion was treated with wet dressings. A small amount of pus drained out, leaving a hole which was larger than the original wound.

The condition did not heal and remained almost stationary in size until about three weeks before his admission to the hospital, when the finger became painful. The pain gradually extended to the other fingers of the hand and became so severe that the patient was unable to sleep. He was admitted to another hospital where studies revealed evidence of occlusion of the radial artery. After a course of treatment, which included the intravenous administration of 5 per cent sodium chloride solution, the symptoms were not relieved and the patient was discharged at his own request.

Physical Examination revealed nothing which appeared to be significant except the condition of the left hand and arm. The tips of the thumb, index and middle fingers showed dry, blackened, gangrenous areas of skin (Fig. 1). The tips of the fourth and fifth fingers were reddened and somewhat sensitive.

In the left supraclavicular region there was a hard, raised structure above which a

¹ Presented before the New York Surgical Society, April 26, 1939. Submitted for publication July 13, 1939.

pulsating vessel could be felt. The left arm showed slight general atrophy and the left hand was definitely cyanotic. The left brachial artery was palpable and pulsating to the junction of the middle and distal thirds of the humerus where pulsation ceased, and beyond that point the artery was felt as a hard, pulseless cord. Pulsation could not be detected in the left forearm, wrist, or hand. The maximal oscillations produced by the left brachial artery were 1 to 1.5 as compared with 4 to 5 for the right. The maximal left radio-ulnar oscillations were scarcely perceptible and were recorded as 0.5, whereas the maximal right radio-ulnar oscillations were 3.5. The temperature of the left hand and forearm was perceptibly lower than that of the right, and color returned slowly after compression. There were no focal areas of sensory or motor disturbance to indicate interference with components of the brachial plexus.

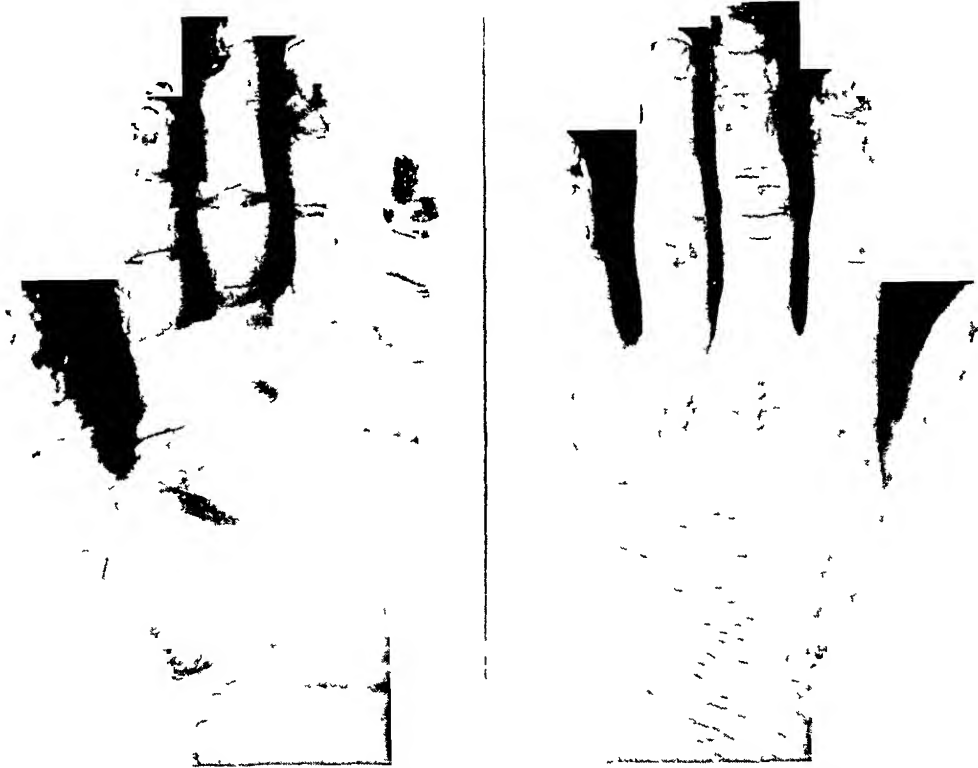


FIG 1—Photographs showing the gangrenous areas on thumb, index and middle fingers

Laboratory Data—The blood and urine showed no significant changes. Roentgenograms of the cervical and upper thoracic spine showed an incompletely developed rib on each side. These appeared to be the first thoracic ribs but they were subsequently proven to be cervical. Each articulated with the first thoracic rib lateral to the scalene tubercle. The anomalous rib on the right side showed greater development than that on the left, but there were symptoms on the left side only. Believing that the left cervical rib was pressing against and partially occluding the subclavian artery, and was responsible for the changes observed in the left arm and hand, operation was undertaken.

Operation—July 9, 1938. The region was exposed through an incision made above and approximately parallel to the left clavicle. The anterior end of the cervical rib formed a rounded, dense cartilaginous mass. The tendon of the scalenus anticus muscle was inserted normally into the first rib and passed very close to the cartilaginous end of the cervical rib. The subclavian artery lay in the narrow space between the scalenus anticus tendon, and the end of rib and was tightly compressed (Fig 2). Immediately distal to the point of compression, the artery presented a fusiform aneurysmal dilatation

of the type which has been frequently observed after the prolonged constriction of an artery. The dilated portion was approximately twice the diameter of the artery above and below. The components of the brachial plexus, lying posterior and lateral to the artery, passed over the cervical rib lateral to the position of the artery and apparently suffered no interference.

The tendon of the scalenus anticus was severed near its attachment. This appeared to completely release the artery which immediately assumed a more medial position. The cartilaginous mass representing the anterior end of the cervical rib was removed by means of a rongeur, although this did not appear to be really necessary.

Subsequent Course—Following operation, relief was immediate and almost complete so far as pain was concerned. There was no immediate return of the radial pulse. Oscillometric readings showed slight improvement, but the objective changes were not commensurate with the subjective relief. The gangrenous processes at the tips of the fingers slowly resolved and healed after sequestration of portions of the terminal phalanges of the index and middle fingers. Nearly six months were required for complete healing. There was gradual improvement in function and in the circulation of the hand and forearm but pulsation at the wrist did not reappear.

The patient was almost free from pain until April 1939 nine months after operation, when he began to experience some discomfort in the region of the left shoulder girdle. At first mild the discomfort gradually increased to a persistent aching pain which radiated along the medial surface of the arm forearm, and hand. It became apparent that the brachial plexus had become involved and, on July 28, 1939, the rib was resected. It was found that the portion of rib removed at the first operation had partially regenerated and there was new bone and scar sufficient to compress the brachial plexus against the clavicle. The aneurysmal dilatation of the subclavian artery, observed at the first operation, had almost disappeared and the vessel at this point was of approximately normal caliber. The painful symptoms subsided after ablation of the rib and, when the patient was last examined, November 28, 1939, five months after the second operation, there was some residual weakness but no pain.

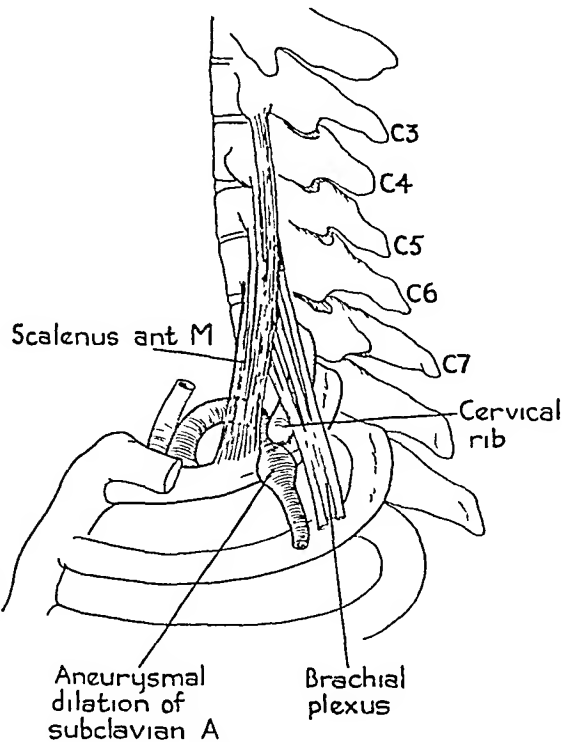


FIG. 2.—Diagrammatic sketch showing the brachial plexus passing over the cervical rib, the subclavian artery compressed between the anterior end of the rib and the tendon of anterior scalene muscle, and the fusiform aneurysm distal to the point of compression.

COMMENT—The chief interest of this case is in the vascular changes, particularly the formation of an aneurysm distal to the point of compression, the apparent obliteration of the artery at a considerable distance peripheral to the site of partial occlusion, and the onset of gangrene in the finger tips.

DISCUSSION—It is noteworthy that nearly all dilatations of the subclavian artery associated with cervical rib have been distal to the point of interference. Baumgartner,² *et al*, and Flint³ have reported cases in which the aneurysm was in direct contact with the sharp edge of a cervical rib. Attempts to explain the dilation of a vessel which occurs beyond a point of

constriction have not been entirely satisfactory. Suggestions which have been offered are: Slowing of the blood stream with a resulting increase of lateral pressure, limitation of blood supply to the vessel wall through interference with the vasa vasorum, and trophic changes in the vascular structure due to paralysis of the sympathetic nerve supply.

In making a study directed toward finding the cause of dilation of the artery distal to the point of compression Halsted and Reid⁴ reviewed 716 cases of cervical rib, taken mostly from the literature. Of this number, 191 were autopsy observations or museum specimens and the remaining 525 were clinical cases. Three hundred sixty of the clinical cases presented symptoms of pressure, 235 had nerve symptoms alone, 106 had nerve and vascular symptoms, and 19, or 5.3 per cent, had only vascular symptoms. In the 125 cases with symptoms which were interpreted as vascular, there were 27 in which a fusiform, aneurysmal, or cylindrical dilatation was observed. In the majority of these the disturbance of circulation was severe, and six cases had gangrene of the fingers.

In a more recent review of 554 cases of cervical rib, collected from the literature, Jacobsen⁵ found six cases with gangrene. A number of single cases with varying degrees of gangrene have been reported, among them may be mentioned those of Pasm,⁶ Otto,⁷ Langeron and Desbonnets,⁸ Lennet,⁹ and Baumgartner.² Two of the cases described by Adson and Coffey¹⁰ had gangrenous changes of the finger tips.

The nature of the vascular lesions and their manner of production are matters which have interested a number of observers. The factor of direct pressure by the anomalous rib has long been recognized, and Adson¹⁰ has called attention to the anterior scalene muscle as an important part of the pressure mechanism. The probable effects of disturbed innervation of the blood vessels have also been considered.

The vascular manifestations associated with cervical rib can hardly be explained on a basis of simple constriction or compression. Todd¹¹ minimized the importance of direct damage to the subclavian artery and came to the conclusion that the vascular symptoms occurring in cases of cervical rib are not mechanical in origin, but are trophic in character and are caused by paralysis of the sympathetic fibers passing to the vessels. It has, furthermore, been shown that grave vascular complications may occur even when the anatomic relations of the cervical rib are such that it impinges only on the brachial plexus and not upon the subclavian artery.^{12, 13}

Leriche¹⁴ also has stressed the importance of disturbed vasomotor function in accounting for the vascular phenomena. On the basis of his experience, he apparently believes that functional vasoconstriction, repeated with sufficient frequency, eventually leads to a true anatomic endarteritis which may persist after removal of the rib and develop on its own account.

In the case herewith reported, Leriche's theory was supported to the extent that the distal portion of the brachial artery and the radial artery were pulseless and apparently obliterated. Pulsation did not return after

liberation of the subclavian artery. There was, however, a definite improvement of circulation with healing of the gangrenous areas of the fingers and an almost complete symptomatic relief which lasted until evidence of pressure upon the brachial plexus appeared nine months later.

With respect to treatment in this case, the severing of the scalenus anticus tendon from its insertion on the first rib appeared to liberate the subclavian artery completely. It appears, in retrospect, that the cervical rib should have been entirely removed at the same time or not disturbed at all. The partial removal was followed by an excessive regeneration, with encroachment upon the brachial plexus and the development of symptoms referable to pressure upon elements of the plexus.

REFERENCES

- ¹ Keen, W. W. Keen's Surgery, 3, Chap. 31, 295, Philadelphia and London, W. B. Saunders Co., 1914.
- ² Baumgartner, A., Clerc, A., and Macrez, C. Sur l'anevrisme arteriel de voisinage et la gangrene ishemique des doigts en rapport avec les cotes cervicales. *Presse Med.*, **46**, 1665-1667, November 12, 1938.
- ³ Flint, E. R. An Unusual Vascular Complication of Cervical Rib. *Brit. Jour. Surg.*, **24**, 622-624, January, 1937.
- ⁴ Halsted, W. S., and Reid, M. R. An Experimental Study of Circumscribed Dilation of an Artery Immediately Distal to a Partially Occluding Band, and Its Bearing on the Dilation of the Subclavian Artery Observed in Certain Cases of Cervical Rib. *Jour. Exper. Med.*, **24**, 271-286, 1916, also *Trans. Amer. Surg. Assn.*, **34**, 273-288, 1916, Philadelphia, also *Surgical Papers*, W. S. Halsted, Johns Hopkins Press, 1924.
- ⁵ Jacobsohn, H. Das Halsrippensyndrom und seine chirurgische Behandlung. *Arch. f. klin. Chir.*, **161**, 398-415, 1930.
- ⁶ Pasini, U. Un caso di costola cervicale con sintomi vascolari. *Chirurgia degli Organi di Movimento*, **4**, 605-607, 1920.
- ⁷ Otto, K. Ein Fall von Halsrippe mit Fingergangran. *Med. Klin.*, **2**, 82-83, January 20, 1924.
- ⁸ Langeron, L., and Desbonnets. Côte cervicale avec troubles vasculaires graves et gangrene de la main. Ablation de la côte. Resection de l'artere sous-claviere obliteree. *Bulletins et Memoires de la Societe Nationale de Chirurgie (Paris)*, **57**, 704-712, May 23, 1931.
- ⁹ Lenner, S. Gangran einer oberen Extremitat, ausgelost durch ein Halsrippe. *Chirurg.*, **10**, 660-664, September 15, 1938.
- ¹⁰ Adson, A. W., and Coffey, J. R. Cervical Rib. A Method of Anterior Approach for Relief of Symptoms by Division of the Scalenus Anticus. *ANNALS OF SURGERY*, **85**, 839-857, June 1927.
- ¹¹ Todd, T. W. The Arterial Lesion in Cases of "Cervical" Rib. *Jour. Anat. and Physiol.*, **47**, 250-253, 1912-1913.
- ¹² Telford, E. D., and Stafford, J. S. B. The Vascular Complications of Cervical Rib. *Brit. Jour. Surg.*, **18**, 557-564, April, 1931.
- ¹³ Blair, D. M., Davis, F., and McKissock, W. The Etiology of the Vascular Symptoms of Cervical Rib. *Brit. Jour. Surg.*, **22**, 406-414, January, 1935.
- ¹⁴ Leriche, R. Quelques resultats eloignes d'operation pour côte cervicale. Analyse du mecanisme varie des accidents vasculaires causes par les côtes cervicales. *Bulletins et Memoires de la Societe Nationale de Chirurgie*, **61**, 1292-1300, December 7, 1935.

PULMONARY EMBOLISM

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PULMONARY EMBOLISM is common enough to keep the surgeon worried, uncommon enough to give him a false sense of security, and erratic enough in its incidence to bolster his faith in any method of preventive treatment. Sudden death from pulmonary embolism following an uneventful recovery from an operation, an injury, or an obstetric delivery is a tragedy that is not soon forgotten. More frequent, less spectacular, but nonetheless disturbing, is pulmonary infarction from a sublethal embolus. Besides these two groups of cases there are many patients who for months or years are incapacitated with thrombophlebitis of one or both legs. That the problem exists no one will question.

Incidence—Wilson,¹ Patey,² Nettleblad,³ Mason,⁴ Bunzel,⁵ Wharton and Pierson,⁶ Dougal,⁷ Murray and Best,⁸ and Cleland and Barlow⁹ inform us that fatal embolism follows 0.1 to 7.5 per cent of surgical operations and that postoperative thrombosis affects 10 to 75 per cent of surgical patients. The discrepancies in reported percentages are due partly to variations in the frequency of thrombosis after certain operations and injuries and partly to the interpretation of findings by the observer. Wharton and Pierson⁶ reported that 40 per cent of the cases diagnosed as pleurisy and 12 per cent of those diagnosed as bronchopneumonia or pneumonia had been in reality instances of pulmonary infarction, and hence due to pulmonary embolism.

Etiology—As embolism is usually a sequela of thrombosis any discussion of the etiology of pulmonary embolism must be primarily a consideration of venous thrombosis.

It is difficult in a study of the causes of thrombosis to decide what are etiologic and what are contributing factors. The following summary, not necessarily complete in detail, includes those conditions which have received most consideration.

- (1) Retarded circulation due to
 - (a) Cardiac weakness
 - (b) Shallow respiration
 - (c) Inactivity
 - (d) Position
 - (e) Low blood pressure
 - (f) Increased intra-abdominal pressure

- (2) Altered metabolism due to
 - (a) Dehydration
 - (b) Low food intake
 - (c) Drugs
- (3) Blood changes affecting the
 - (a) Platelets
 - (b) Clotting mechanism
 - (c) Chemistry
- (4) Tissue trauma
- (5) Infection
- (6) Vessel wall changes
- (7) Obesity
- (8) Age

Discussion—Nichow¹⁰ is often quoted as the first to consider retarded circulation as an important cause of thrombosis. Welch,¹¹ in 1899, in a very comprehensive review of thrombosis and embolism, stressed the importance of enfeebled circulation, but added that some other factor such as increase in the platelets, or a change in the composition of the blood might be important. He also discussed what Aschoff later demonstrated—that fibrin coagulation is not the first stage in thrombus formation. Aschoff¹² described white or static thrombi which are laid down on the wall of the vessel and consist of platelets and leukocytes. To this white thrombus the red thrombus consisting of the elements of coagulation is later attached. "The white thrombus is the determining and peculiar factor in the whole process; the red thrombi are only so to speak, incidental, the first stage is the erection of a morphologic structure by a process of agglutination. Fibrin ferment is obtained from the agglutinated elements and cements them together by coagulation." The original process has nothing to do with the coagulability of the blood but rather with that factor which allows the platelets and leukocytes to accumulate. A reproduction from his lecture illustrates his conception of how the change in the rate of flow and the eddies in the blood stream are conducive to the deposition of blood elements on the venous walls (Fig. 1). In discussing John Hunter's observation that blood will not coagulate in a segment of vein tied off, Aschoff says that for intravascular clotting not complete stagnation but retardation of the blood flow is necessary to allow the accumulation of platelets.

Belt¹³ states that pulmonary embolism, usually regarded as a postoperative complication, is more often associated with medical than surgical cases. From the Department of Pathology of the Toronto General Hospital, he reports pulmonary emboli in 10 per cent of 567 autopsies. Of these 56 cases, 37 were considered the immediate cause of death and only 11 had undergone operative treatment. He further observed that there was a history of some cardiac impairment in 49 of the 56 cases of embolism. He concludes that retardation of blood flow is the important factor in intravenous clotting. He found no infection in the clots and no microscopic changes in the intima of the veins.

in which the thrombus developed Henderson,¹⁴ likewise, found that cardiovascular disease was the predominant illness in one-half of the nonsurgical cases of embolism

From the studies of Blumgart and Weiss,¹⁵ on the rate of blood flow, we learn that the arm-to-arm circulation in normal male individuals averages 18 seconds. In compensated cardiovascular disease the circulation time is 24 seconds, and in decompensated individuals 38 seconds. He states "In general, the degree of cardiac decompensation at the time of the test was closely related to the degree of retardation of the velocity of the blood flow."

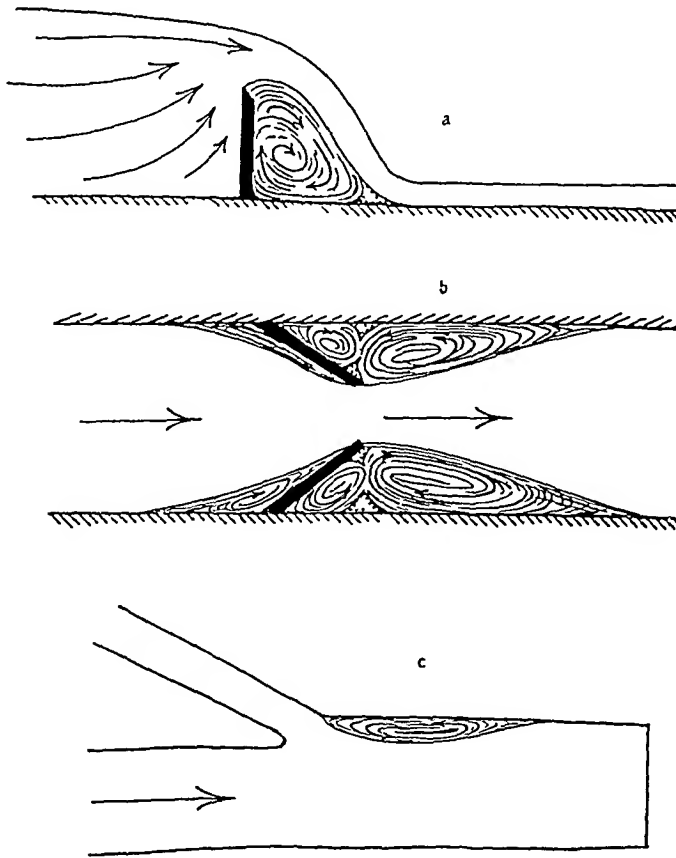


FIG 1.—Diagrams showing (a) eddy formation behind a weir (b) eddy formation in front of, behind and beneath obliquely placed weirs, (c) eddy formed at the point of junction of two streams of unequal size (From Aschoff: *Thrombose und Sandbankbildung* Ziegler's Beitr., 52: 209, 1912.)

Respiration is an important accessory factor in aiding the circulation (Howell¹⁶ and Wiggers¹⁷). The negative intrathoracic pressure produced with each inspiration tends to aspirate the blood into the large veins of the thorax. During long or forced expiration the large veins become distended—easily observed in the external jugulars—and during inspiration they collapse quickly. Keith¹⁸ states that emptying of the "venous cistern" of the abdomen and pelvis is aided by respiratory movements and muscle contractions. It must follow, then, that the return flow of venous blood is hampered when respiration is shallow as it is during severe illnesses and following abdominal operations.

Patey² pointed out that the normal variations in intra-abdominal pressure due to respiration are an important mechanism in aiding the return flow of blood

The inactivity of bed rest, which is of necessity enforced upon each sick person, adds to the tendency toward venous stasis. In McCartney's¹⁹ report of 73 cases of pulmonary embolism there were 15 strictly posttraumatic cases, 12 of which had lower extremity fractures and all of which were confined to bed. When the muscles of the legs and abdomen are inactive there is little alteration in the rate of blood flow in the pelvic and femoral veins. Thrombi practically never form in the axillary veins of postoperative patients. The reason for this, it is assumed, is that the beginning of any accumulation of platelets is prevented or is promptly swept out, before a thrombus can form, by frequent alterations in the rate of blood flow produced by muscular contractions and elevation of the arms. Thrombosis and embolism are relatively common in fracture patients confined to bed in plaster encasements, especially those with fracture of the neck of the femur, but it is rare in ambulatory patients with arm, leg, shoulder or spine fractures in encasements. Both groups are free from demonstrable infection. The amount of tissue trauma is the same in each. The importance of inactivity and position as factors in thrombosis looms large. With the lowering of blood pressure the rate of blood flow correspondingly falls. This affords an opportunity for the fixed elements of the blood to settle out. Walters²⁰ reported an average drop in blood pressure of 30 Mm Hg in postoperative patients.

Increased intra-abdominal pressure due to ileus, meteorism, and intestinal stasis follows practically all abdominal and many extra-abdominal operations. In abdominal distention of any degree pressure transferred against the inferior vena cava and the iliac veins hinders the normal return flow of blood from the legs.

The metabolism of the postoperative patient is profoundly altered. There may be psychic depression from the fear of surgery, toxemia from anesthesia and trauma, and shock from the loss of blood. Withholding preoperative fluids, sweating, vomiting and blood loss contribute to dehydration with consequent increase in the fixed elements of the blood. Inadequate food and inactivity lower the metabolism. Sedatives such as morphine and barbituric acid derivatives depress it still further.

Ever since the importance of the platelets was pointed out by Welch and Aschoff they have been studied vigorously. Hueck,²¹ and Dawbarn, Earlam, and Evans²² found a platelet rise from the sixth to the tenth postoperative day, the more extensive the operation the greater the rise in the platelet count. Wells²³ says that numerous studies on the relationship of the platelets and disease conditions have indicated a certain parallelism between their numbers and the tendency to coagulation observed in various disease conditions. On the contrary, Allen²⁴ found no uniform or significant variations in the platelet count in postoperative patients. Armitage, Pickering, and Mathur²⁵ add that the complete disintegration of blood platelets, produced with saponin, neither

produces intravascular clotting nor hastens the coagulation of normal blood which has been shed into paraffined vessels

The mechanism of blood coagulation has long been fairly well known. The search is for those factors which will inhibit this mechanism within the vessels. Blood is a "streaming suspension" and anything which thickens the solution and slows its progress would seem to be of importance on the basis of pure mechanics in initiating the process. Earlam²² hinted at the possibility of some coagulation inhibiting factor in the walls of the vessels themselves. Some writers have surmised that individual idiosyncrasies toward coagulation are of importance. Bancroft and his coworkers²⁶ are attempting by means of a plasma clotting test to seek out those patients who are susceptible to thrombosis. They divide all patients into three groups. Those with a tendency to bleed, those with normal clotting time, and those with a tendency to clot. The last group constitutes 12 per cent of patients.

Changes in the blood chemistry of postoperative patients are in general those found in cases of dehydration. A rise in the urea content of the blood has been demonstrated. Duval and Binet²⁷ stressed the importance of polypeptides as an important factor in pulmonary complications. Homans²⁸ sums up his view with this statement: "Blood chemistry, except for dehydration, is not a factor in thrombosis."

The release of tissue extracts—"tissue juices"—into the circulation by trauma has long been an attractive theory of thrombosis and is favored by Mason⁴ who says: "The potency of such an extract has not been fully appreciated, for it requires only 0.003 Gm. of lung tissue extract to produce complete intravascular coagulation throughout a rabbit." Portal thrombosis following operations on the gallbladder, stomach and intestines is rarely observed, even though the portal vein is flooded with tissue extracts. Patey²⁹ injected tissue extract into the peritoneal cavity of dogs and found no subsequent thrombosis. If tissue extracts in the circulation were of great importance, thrombosis should extend from the site of operation, but actually the site of operation has little to do with the point at which thrombosis begins. Radical breast operations, which are very traumatic, are rarely followed by thrombosis while operations in the pelvis, especially prostatectomies, more commonly are. In patients with cardiac decompensation there is no greater release of thrombokinasase, if any, than in other correspondingly ill patients and yet the former, as pointed out by Belt, have thrombosis far more frequently.

Over 100 years ago, Cruveilhier³⁰ became the chief exponent of the infection theory of thrombosis. He regarded the inflammatory changes in the vein as primary and the clotting of the blood as a secondary factor. Rosenow³¹ isolated a diplostreptococcus from thrombi. Whether the organism was the cause or whether it lodged there after the thrombus had formed remains a question. Lockhart-Mummery³² states, rather definitely, that he does not believe sepsis is the cause of pulmonary embolism. Repeated observations indicate that "clean" operations are more apt to be followed by fatal embolism than those complicated by infection. Sudden fatal embolism strikes without

warning the patient who has made an uneventful postoperative recovery, while nonfatal and repeated pulmonary emboli more commonly follow clinically recognizable thrombophlebitis. If infection is an important cause of thrombosis why is the incidence of thrombosis and embolism greater, as it is, following fracture of the neck of the femur than following operations for suppurative appendicitis? Why should bacteremia cause thrombosis of the pelvic and femoral veins and not of the axillary? Furthermore, why should it pick out the left leg more commonly than the right?

Vessel wall changes beneath thrombi are conspicuous by their absence. Aschoff, Welch and Belt found no gross or microscopic changes in the walls of the vein beneath a simple thrombus. If pathologic alterations in the vessel walls were of any consequence, thrombosis should be frequent in the arterial trunks where vessel changes are commonly extensive and rare in veins which show few if any changes. The opposite is true. After an exhaustive post-mortem study of fatal embolism Patey²⁹ concludes "The veins in these subjects are exasperatingly normal."

Snell³³ called attention to the fact that the obese patient is more subject to embolism than the patient of average weight.

The average age of cases of thrombophlebitis is about 50 years, although it is not uncommon in the twenties.

Prevention—During the past decade, most of the efforts toward the prevention of pulmonary embolism have been directed toward combating venous stasis.

Kiecke,³⁴ in 1910, advised deep breaths for postoperative patients, and active and passive movements of the legs and massage.

Pool,³⁵ in 1913, developed a rather elaborate system of exercises for the arms, legs and head beginning on the third postoperative day. He also advised deep breathing exercises. No ill effects were observed following these procedures.

Blair Bell³⁶ states that with the adoption, in 1916, of systematic exercises accompanied by deep breathing, the Gynecologic Service at the Royal Infirmary had changed from the head of the list in both number and percentage of deaths to the bottom of the list.

Walters,²⁰¹ in 1927, advised thyroid extract postoperatively to combat stasis and low blood pressure, and thereby reduced the incidence of pulmonary embolism from 0.34 to 0.09 per cent. He combined with this treatment movement of the arms and legs and frequent turning.

Decourcy³⁷ said "I am one of those that believe that venous stasis is the most essential factor in the etiology of postoperative embolism." To combat stasis he places his patients in a reverse Fowler position by elevating the foot of the bed six inches. Schmid,³⁸ likewise, advises that the foot of the bed be raised 25 cm immediately after operation and be left there four or five days.

Payr³⁹ obtained leg action by urging patients to work a wooden roller placed at the foot of the bed.

Gamble⁴⁰ has a bicycle-like device which patients are asked to "wheel" in bed. He also advises carbon dioxide inhalations the first postoperative day and deep breathing exercises thereafter.

Patey⁴¹ recently suggested postoperative elevation of the head so that patients developing a thrombophlebitis might develop an extensive thrombus which would stick.

Baines⁴² emphasizes the importance of accelerating the return flow of blood from the lower extremities. He reports that one of the surgical services at the Mayo Clinic has adopted the following regimen: The Trendelenburg position for the first 24 hours after operation, carbon dioxide inhalations several times day and night during the first 48 hours, and deep breathing, active and passive exercises and massage of the legs until the patient is out of bed.

Bancroft²⁶ administers sodium thiosulphate to that group of patients whose plasma clotting index is high. He advises exercise as well.

Murray and Best⁸ have recently advanced the possibilities of heparin as an anticoagulant for postoperative patients. It has been proven effective in blood vessel surgery. To give all surgical patients continuous heparin solutions intravenously for a number of days postoperatively is obviously difficult and at present economically impossible. If Bancroft's plasma clotting index will successfully pick out those few patients with tendencies to thrombosis, heparin may become a valuable addition to the armamentarium for combating postoperative pulmonary embolism.

From the above review it is apparent that the general trend of medical opinion has been toward support of venous stasis as the primary contributing factor in thrombosis and embolism. Most men agree that activity is essential for postoperative patients, but few have followed through with a definite scheme of exercises easy of accomplishment.

Clinical—Believing that deep inspiration, leg elevation and muscular contraction will assist in sweeping out the pelvic and femoral veins, it was decided, in 1928, to adopt postoperative exercises routinely whenever possible. The following order, taking effect the morning after operation, was written for patients above 12 years of age. (The few exceptions were those seriously ill patients who were unable to carry them out and those who, it was thought, should conserve their strength.) *Have the patient take 15 deep breaths morning and evening and with each deep breath actively flex the legs.* It was concluded from experiments on dogs (to be reported later) that the combination of a deep breath with *active* flexion of the legs would be most effective, the deep breathing tending to aspirate the blood from the pelvic basin, contraction of the leg muscles squeezing the blood into the veins and elevation of the knees making the blood run out of the femoral veins by gravity. The choice of 15 deep breaths and leg flexions and their repetition twice a day was entirely arbitrary.

The amount and type of postoperative activity are too frequently left to the discretion and memory of the floor nurse. It is necessary to explain to the

nurse in charge, and frequently to the patient, how the above order is to be carried out. If the postoperative exercises are of value—and most surgeons believe they are—the necessity of having them carried out routinely by *written order* is apparent.

Results—I hesitate to write the following sentence because pure coincidence so often leads us astray in evaluating therapeutic procedures. In no case during the past 11 years, during which period this regimen has been carried out, has there been a case of pulmonary embolism or thrombophlebitis. During this period, 518 adult patients underwent major surgical procedures and carried out the above breathing and leg exercises. The operations consisted of appendicectomies, cholecystectomies, common duct explorations, gastro-interostomies, intestinal obstructions, colon resections, exploratory celiotomies, herniotomies (inguinal and ventral), thyroidectomies, radical breast amputations, *etc.* Operations upon children under 13 years of age, minor cases such as hemorrhoidectomies, benign breast tumors and minor infections—in fact, all cases requiring a short hospital stay and only partial restriction of activity—are not included.

While the series of cases is small it assumes some importance when it is contrasted with the group of patients who served as controls. In this group were 95 patients with fractures of the leg, thigh, hip, pelvis or spine. All were confined to bed and completely inactive in leg or body encasements, or traction. Five cases of thrombophlebitis developed, three of which were followed by nonfatal pulmonary emboli. They are briefly reviewed.

ABBREVIATED CASE REPORTS

Case 1—Mrs W, age 33, developed extensive thrombophlebitis in the left femoral vein 14 days after fracture dislocation of the right sacro-iliac joint. Slow resorption followed but swelling of the leg persisted for four years.

Case 2—Mr H, age 65, was confined to bed with multiple bruises and a fracture of the external condyle of the left tibia which was immobilized in a plaster encasement from toes to groin. On the twenty-first day after injury, thrombophlebitis involved the left femoral and iliac veins causing extensive edema of the entire leg, groin and left half of the abdominal wall. Pulmonary infarction of the left lower lobe followed a few days later but cleared spontaneously.

Case 3—Mrs C, age 67, immobilized in a Whitman abduction spica for fracture of the neck of the left femur, had an infarct of the lower lobe of the right lung eight days after the spica was applied. Thrombophlebitis did not manifest itself until five days later, when swelling of both legs and the pelvis became so marked that the spica had to be split. The pulmonary infarction cleared spontaneously, after a very critical period, under conservative treatment. Swelling of both legs persisted for months. The fracture healed.

Case 4—Mr E, age 42, developed a very mild thrombophlebitis in the left leg following open reduction of a fracture of the patella. Two minor pulmonary infarctions, one associated with expectoration of blood, occurred after the patient had been discharged from the hospital.

Case 5—Mr B, age 31, had a severe fracture dislocation of the first lumbar vertebra which completely severed the spinal cord. He died six days after injury. Although there were no clinical signs of thrombophlebitis during life, at autopsy a large white and red thrombus was found in the right iliac vein and one embolus in the lung.

RLSUME

(1) From a review of medical literature, and from my experience, stasis is one of the most important causes of venous thrombosis

(2) It appears that routine breathing and leg exercises are of value in the prevention of postoperative thrombosis and embolism. Only years of experience with many cases can finally prove the value of this procedure. I have been able to detect no ill effects from it. Certainly, the exercised patients feel less weakened when they get out of bed than those who have been inactive.

(3) No clinically recognizable thrombosis or embolism occurred in 518 patients who, postoperatively, carried out these exercises.

(4) Five cases of thrombophlebitis, three of which were associated with nonfatal pulmonary embolism, occurred in the control group of 95 patients with fractures which required complete immobilization.

BIBLIOGRAPHY

- ¹ Wilson, L. B. Fatal Postoperative Embolism. *ANNALS OF SURGERY*, 56, 809, 1912
- ² Patey, D. H. The Effect of Abdominal Operations on the Mechanism of Respiration. *Brit Jour Surg*, 17, 487, 1929-1930
- ³ Nettleblad, A. Studien an den Krankengeschichten des Thrombosenmaterials der Gebäranstalt, Stockholm-Süd aus den Jahren, 1912-1927. *Acta Obst et Gynec Scandinau*, 11, 165-244, 1931
- ⁴ Mason, E. C. Blood Coagulation. The Production and Prevention of Experimental Thrombosis and Pulmonary Embolism. *Surg, Gynec and Obstet*, 39, 421, October, 1924
- ⁵ Bunzel, E. E. Pulmonary Embolism Complicating Pregnancy, Labor and Puerperium. *Am Jour Obst and Gynec*, 13, 584-591, May, 1927
- ⁶ Wharton, L. R., and Pierson, J. W. Minor Forms of Pulmonary Embolism after Abdominal Operations. *J A M A*, 79, 1904-1910, December 2, 1922
- ⁷ Dougal, D. The Etiology of Thrombosis and Embolism. *Jour Obst and Gynec, Brit Emp*, 45, 425-450, June, 1938
- ⁸ Murray, G. D. W., and Best, C. H. The Use of Heparin in Thrombosis. *ANNALS OF SURGERY*, 108, 163-177, August, 1938
- ⁹ Cleland, J. B., and Barlow, D. L. Deaths from Pulmonary Embolism. *Med Jour Australia*, 1, 175-176, February 18, 1922
- ¹⁰ Virchow, R. *Arch Path*, Berlin, 1856
- ¹¹ Welch. Thrombosis and Embolism. *Albutt's System of Med*, 7, 155-285, 1899
- ¹² Aschoff, L. The Cartwright Lectures. *Arch Int Med*, 12, 503-525, 1913
- ¹³ Belt, T. Thrombosis and Pulmonary Embolism. *Am Jour Path*, 10, 129, 1934
- ¹⁴ Henderson, E. F. Fatal Pulmonary Embolism. Statistical Review. *Arch Surg*, 15, 231-236, August, 1927
- ¹⁵ Blumgart and Weiss. Studies on the Velocity of Blood Flow. *Jour Clin Invest*, 4, 15-31, 149-209, 1927, 5, 343-392, 1927-1928
- ¹⁶ Howell. Textbook of Physiology. 11th Ed., W. B. Saunders and Co., 1930
- ¹⁷ Wiggers. Physiology in Health and Disease. Lea and Febiger, 1934
- ¹⁸ Keith, A. *Jour Anat and Physiol*, 42, 1, 1908
- ¹⁹ McCartney, J. S. Pulmonary Embolism. *Arch Path and Lab Med*, 3, 921-937, 1927
- ²⁰ Walters, W. The Suggested Use of Thyroid Extract to Reduce the Incidence of Postoperative Embolism. *Minnesota Med*, 10, 25-28, 1927
- ^{20a} Walters, W. A Method of Reducing the Incidence of Fatal Postoperative Pulmonary Embolism. *Surg, Gynec and Obstet*, 50, 154-159, January, 1930

- ²¹ Hueck, H Blutplattchenveränderung nach Operationen Munchen med Wchnschr , 73, 173, 1926
- ²² Dawbarn, R Y , Earlam, R , and Evans, W H The Relation of the Blood Platelets to Thrombosis after Operation and Parturition Jour Path and Bact , 31, 833-873, 1928
- ²³ Wells, H G Chemical Pathology 5th Ed , W B Saunders and Co , 352, 1926
- ²⁴ Allen, E V Changes in the Blood Following Operation Arch Surg , 15, 254-264, 1927
- ²⁵ Armitage, E, Pickering, J W , and Mathur, S N Inception of Blood Clotting Biochem Jour , 26, 853-864, 1932
- ²⁶ Bancroft, F, Stanley-Brown, M , Quick, A J Postoperative Thrombosis and Embolism Am Jour Surg , 28, 648-668, 1935
Bancroft, F, Stanley-Brown, M , and Chargaff, E Postoperative Thrombosis and Embolism ANNALS OF SURGERY, 106, 868-979, June, 1937
- ²⁷ Duval, P , and Binet, L Essai Experimental sur la Pathogenie de certaines Complications postoperatoires Med Acad de Chir , 62, 181-192, February 12, 1936
- ²⁸ Homans, J In Discussion of Bancroft's²⁶ Paper
- ²⁹ Patey, D H Discussion on Postoperative Thrombosis Proc Roy Soc Med , 22-1, 733, 1929
- ³⁰ Cruveilhier Cited by Dougal
- ³¹ Rosenow, E C Bacteriologic Study of Pulmonary Embolism Jour Infec Dis , 40, 389-398, 1927
- ³² Lockhart-Mummery, P Discussion of Postoperative Pulmonary Embolism Brit Med Jour , 2, 850-854, 1924
- ³³ Snell The Relation of Obesity to Fatal Postoperative Pulmonary Embolism Arch Surg , 15, 237-244, 1927
- ³⁴ Krecke, A Über Vor-und Nachbehandlung bei Bauchoperationen insbesondere über das Frühzeitige Aufstehenlassen Munchen med Wchnschr , 57-2, 1, 2037-2041, 1910
- ³⁵ Pool, E H Systematic Exercises in Postoperative Treatment J A M A , 60, 1202, 1913
- ³⁶ Blair, Bell Discussion of Prof Glynn's Paper on Pulmonary Embolism Jour Obst and Gynæc , Brit Emp , 31, 521, 1924
- ³⁷ Decourcy, J L Venous Stasis as Cause of Postoperative Embolism Its Prevention by Use of Reverse Fowler Position after Lower Abdominal Operations Anaesthesia and Analgesia, 8, 342, 1929
- ³⁸ Schmid, H H Verhütung von Thrombosen und Embolien Arch f Gynaek , 161, 401-404, 1936
- ³⁹ Payr, E Gedanken und Beobachtungen über die Thrombo-Emboliefrage Zentralbl f Chir , 57-1, 961-979, 1930
- ⁴⁰ Gamble, H A The Prevention of Postoperative Embolism and Phlebitis Am Jour Surg , 28, 93-95, 1935
- ⁴¹ Patey, D H Artificially Induced Thrombophlebitis Surg , Gynec and Obstet , 64, 1002-1004, June, 1937
- ⁴² Barnes, A R Pulmonary Embolism J A M A , 109, 1347-1352, October 23, 1937

THE INFLUENCE OF CONGESTION UPON TUBERCULOSIS IN THE LUNG OF THE DOG

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IN A previous communication by Hyndman and Landt,¹ it was stated that no reference could be found concerning the effect of pulmonary vein ligation on pulmonary tuberculosis. The authors have since learned, however, that Walsh² suggested this as a therapeutic possibility in 1907. Walsh was stimulated by the fact that pulmonary tuberculosis and mitral insufficiency are infrequently associated. His work consisted in an attempt to ligate the pulmonary veins of dogs but the operative mortality was 100 per cent since no precaution was taken to prevent collapse of the lungs when the chest was opened.

In continuing our studies relative to congestion, we selected the dog because we expected to be provided with a progressive pulmonary lesion after endobronchial injection of virulent human tubercle bacilli. Although Fishberg³ states that pigs, dogs, cats and sheep are not at all affected by human tubercle bacilli, Petit and Panisset⁴ found that after endobronchial or transpulmonary injection into the lung of the dog and horse, a progressive lesion was initiated which remained limited to the lungs and which produced caseation and cavitation much the same as is found in the human. Opie⁵ states that tuberculosis occurs with reasonable frequency among both domestic and wild Carnivores throughout the world, its incidence being 3 to 5 per cent in dogs and 0.5 to 2 per cent in cats. The lesion is a fibrocaseous mass with cavitation. Although our first animal died with overwhelming pulmonary tuberculosis three months after endobronchial injection of 0.2 cc. of milky suspension, there was only one other progressive lesion in a group of 24 dogs receiving 1 to 3 cc. of a milky suspension of bacilli into each lung.

In a previous experiment with guinea-pigs¹ the authors stated a conviction that a progressive lesion is necessary in the controls, if a proper test of any therapeutic device is to be made. Upon this basis, we would have to eliminate the dog as a suitable experimental animal for our purposes. However, the difference in manner of healing of a tuberculous lesion in the congested as compared with the uncongested lung was so striking that we feel it worthy of publication. This obvious difference in the manner of healing applies only to those lesions produced by endobronchial administration of large doses of tubercle bacilli.

Operative Procedure—All intrathoracic operative work was performed

Submitted for publication February 17, 1939

under positive pressure ether anesthesia, using the simple and effective apparatus described by Livingston and Hidana⁶ Dogs of average size received 1 g of morphia intramuscularly one-half hour preceding anesthesia

It was concluded that the left side was more suitable than the right for ligation of the pulmonary veins, as on the left the veins enter the hilus as three definite trunks, easily available for the passage of a ligature, while on the right, the trunks divide early into smaller branches and the branching is inconstant. Ligation of all of the veins on the left at one operation was concluded to be advisable and not in the least incompatible with life

Through an incision three inches long in an interspace opposite the xiphoid process, a ligature of black silk was passed around each of the three pulmonary veins on the left and tied securely

After ligating a vein, the lobe which is drained by that vein immediately assumes a brick-red color and there is a slight appearance of cyanosis in the unligated lobes. The cause of this phenomenon is obvious, but it illustrates that when dealing with congestion of the pulmonary circulation one is faced with factors that are different from those in other tissues, inasmuch as stagnant blood in the pulmonary circulation becomes saturated with oxygen rather than carbon dioxide. The effects of obstructed venous flow soon manifest themselves, however, for within 24 hours the affected lung becomes swollen, boggy, dark purple and nonan containing. The liver-like consistency appears not unlike that in the red hepatization of lobar pneumonia. Microscopically, the parenchyma presents a mass of closely packed red blood cells among which the alveolar outlines are greatly obscured. At this stage there is a small amount of thin, serosanguineous fluid in the pleural cavity and in the bronchi of the affected side

After a month, it is very striking to see how the completely ligated lung has become restored. The visceral pleura becomes thickened but is adherent to only the line of incision. The interlobar pleural surfaces, however, become firmly adherent with considerable scar formation. Scar tissue is strikingly absent throughout the parenchyma. There is evidence of acute emphysema with rupture of alveolar walls, and this change occurs to some extent in the unoperated lung. Otherwise the operated lung is an containing and functioning

PART I

ORGANISMS DISSEMINATED BY INTRAVASCULAR ADMINISTRATION

Fresh suspensions of tubercle bacilli in normal saline were made for each day's experimentation by shaking cultures of six weeks' growth with glass beads. The Gluckson human strain* was used and subcultures made on glycerin gentian violet potato media

Exper I, October 21, 1931—Under positive pressure ether anesthesia, 0.2 cc of a

* We were provided with the Gluckson strain through the kindness of H. J. Corper

milky suspension of bacilli diluted in 6 cc normal saline was injected into the right ventricle of the heart. After five minutes the vein to the upper lobe of the left lung was ligated.

November 6, 1931—Under anesthesia, the left chest was opened. No evidence of tuberculosis was seen on the surface of the entire left lung. The left upper lobe of the lung was adherent firmly to the middle lobe. There was no gross appearance of congestion.

November 30, 1931—Forty days after inoculation, the animal was killed and presented no evidence of tuberculosis in the lungs, liver, spleen or kidneys.

Exper II, October 21, 1931—Same as Exper I, except 0.1 cc of suspension was used in 6 cc saline and the vein to the left middle lobe was ligated.

March 2, 1932—One hundred and thirty-two days after inoculation, the animal was killed and showed no evidence of tuberculosis in the lungs (microscopically) or grossly in the liver, spleen or kidneys. The left middle lobe was adherent to the upper and lower lobes. It was slightly contracted but on a cut-surface appeared almost as air containing as the upper and lower lobes.

Exper III, October 22, 1931—A small mongrel received 1 gr of morphia. Two-tenths cc of a milky suspension of bacilli diluted in 6 cc normal saline was injected into the left femoral vein.

March 21, 1932—One hundred and fifty days after inoculation the left chest was opened under anesthesia. No evidence of tuberculosis was seen on the surface of the left lung. All three veins to the left lung were ligated. The incision was closed and 3 cc of a milky suspension of bacilli injected into the left femoral vein.

April 21, 1932—Twenty-two days after ligation and second inoculation, the animal was killed. Miliary tubercles averaging 2 Mm in diameter were rather evenly scattered over the pleural surfaces of both lungs. The parenchyma revealed no gross lesion. There was no appreciable difference in the number, size or microscopic character of the lesions on the two sides.

Exper IV, October 22, 1931—A small mongrel received 1 gr of morphia. Two-tenths cc of a milky suspension of bacilli diluted in 6 cc normal saline was injected into the left femoral vein.

December 22, 1931—Sixty days after inoculation the left chest was opened under anesthesia. No evidence of tuberculosis was seen on the surface of the left lung. All three veins were ligated.

March 2, 1932—One hundred and thirty-one days after inoculation, animal was killed and revealed no tuberculosis (microscopically) in the lungs or grossly in the liver, spleen and kidneys.

Exper V, July 12, 1932—Two small mongrels received each 1 gr of morphia. Three cc of a milky suspension of bacilli were injected into the left femoral vein of each. One animal died in 41 days and the other in 44 days. Both revealed an overwhelming miliary seeding of the visceral pleura and enough involvement of the parenchyma to give the lung a "shotty" feel.

SUMMARY—As much as 0.2 cc of a milky suspension of bacilli injected into the right heart or femoral vein failed to produce evidence of tuberculosis in the lungs in 40 to 150 days.

In one dog, all left pulmonary veins were ligated and 3 cc of a milky suspension injected into the femoral vein. After 22 days the pleura of both lungs was studded with miliary tubercles. There was no gross or microscopic difference in appearance of the tubercles on the two sides and they were approximately equal in number.

Two dogs received each 3 cc of a milky suspension intravenously and died in 41 and 44 days with overwhelming miliary seeding. The visceral pleura was markedly studded but the parenchyma was much less involved.

CONCLUSIONS

(1) Dogs are considerably resistant to human tubercle bacilli injected into the blood stream

(2) Pulmonary congestion appears to have no influence upon the number or pathologic character of tubercles which develop in the pleura, after intravascular injection (one dog)

PART II

ENDOBONCHIAL ADMINISTRATION OF ORGANISMS

Dogs of average size received $\frac{1}{2}$ to 1 g. of morphia intramuscularly and in one-half hour an intraperitoneal injection of a 10 per cent aqueous solution

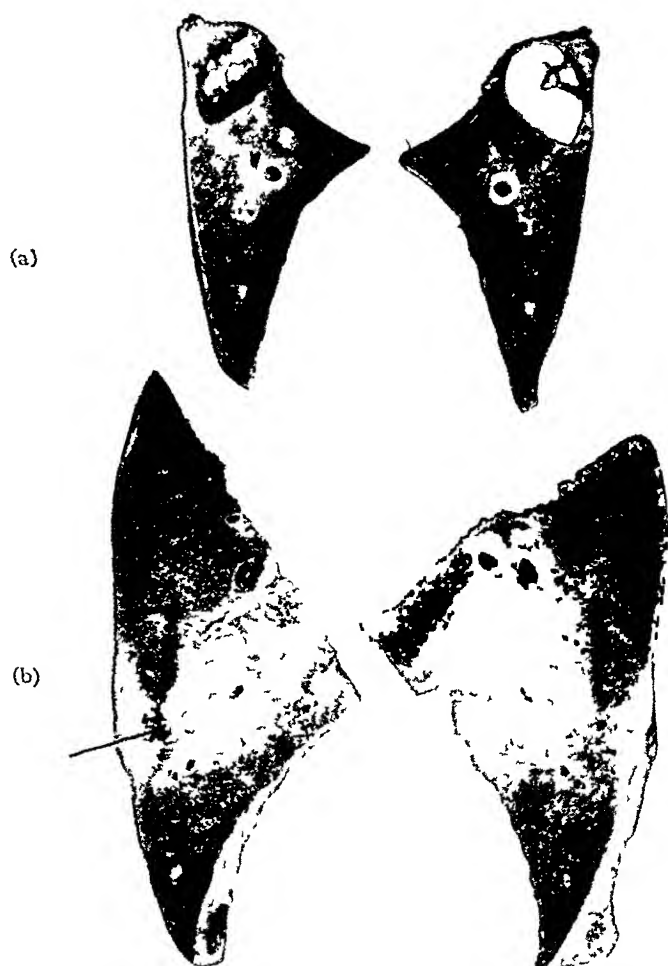


FIG 1—Dog No. 16 (a) Showing cavity with obliterated vessels in unoperated lung, middle lobe (b) Showing scar formation in operated lung, lower lobe

of sodium amytal (55 mg per kilo of body weight) With the aid of a bronchoscope, a ureteral catheter was placed in a primary bronchus as far as it would go A suspension of tubercle bacilli was then injected with the lung in a dependent position The inoculum was followed by several syringes full

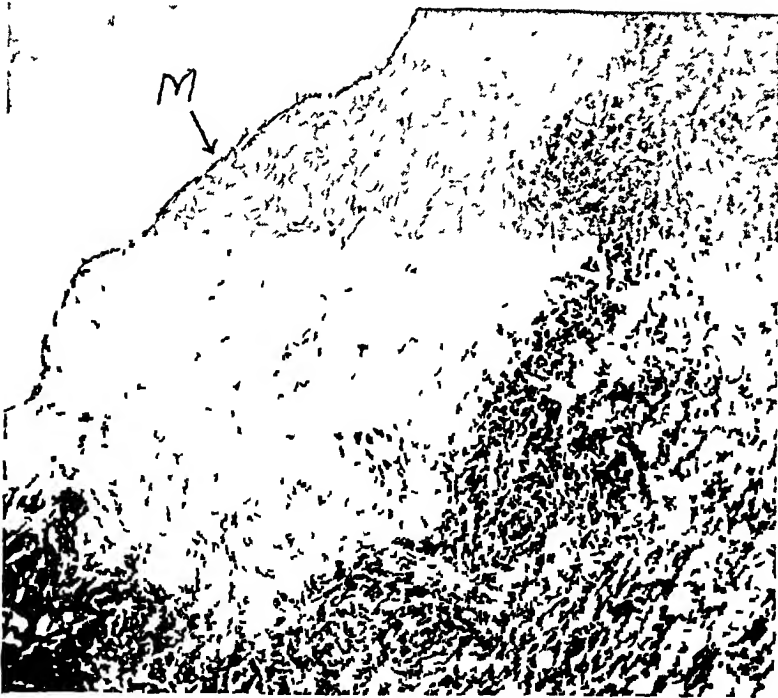


FIG 1 (c) —Photomicrograph of section taken from (a) M Margin of cavity



FIG 1 (d) —Photomicrograph of section taken from lesion in (b) There is a greater degree of vascularization of the caseous tissue than in (c)

CONGESTION AND TUBERCULOSIS

of air to empty the catheter. The same dose was always injected in each side.

Microscopic Appearance of Lesions—Lesions produced in this way revealed caseation with surrounding atelectasis and cellular infiltration. Endothelioid cells, small round cells and desquamated pigment containing alveolar cells filled alveolae. Giant cells were never seen.

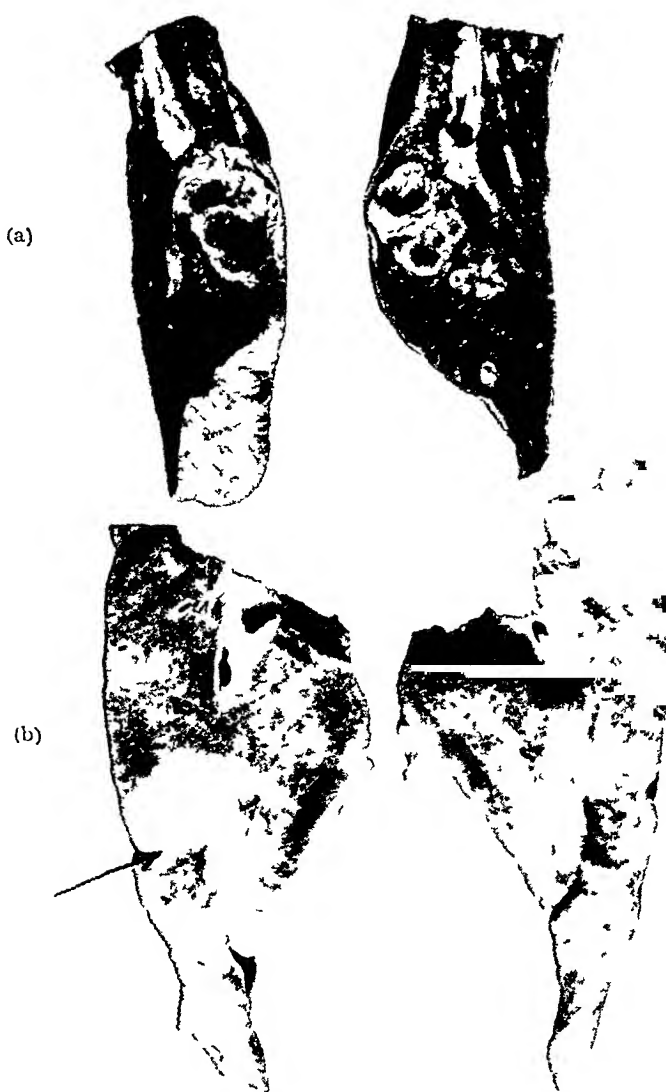


FIG. 2—Dog No. 21. (a) Showing cavity in unoperated lung, lower lobe. (b) Showing diffuse healing lesion without cavitation in operated lung, lower lobe.

The only microscopic difference of any possible significance that could be detected in the congested and the uncongested lungs is that in the former there seemed to be a greater tendency toward vascularization with no sharp transition between caseous and viable lung, and this was evident to a striking degree in only one animal. In the uncongested lung the caseous tissue was rather sharply delimited from viable tissue (Fig. 1).

EXPERIMENTS

Dog No. 16, February 25, 1932—One-half cc. milky suspension (Gluckson strain) deep into each main bronchus.



FIG 3—Dog No 29 (a) Showing external appearance of lungs. Note the pleural thickening on the operated side (L). The shaggy portion was adherent to the line of incision in the parietal pleura. Large lesions may be seen in both lower lobes.

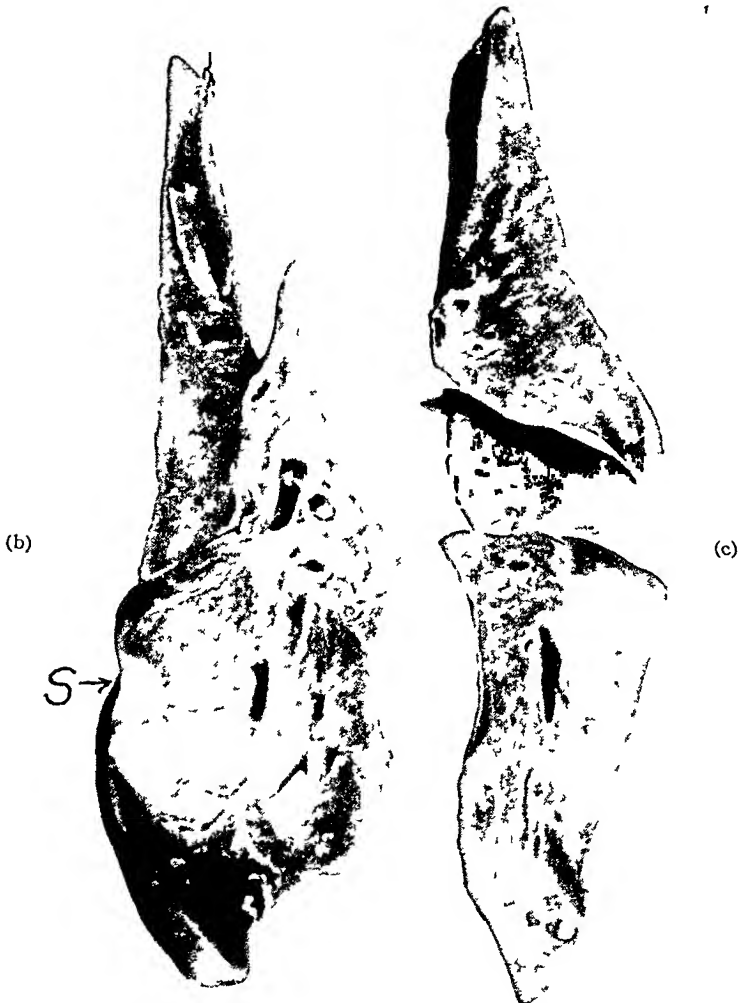


FIG 3 (b)—Cut surface of operated lung showing a contracting scarred lesion (S) and a large caseating lesion without cavitation. (c) Cut surface of unoperated lung showing discrete caseating lesions in lower lobe with beginning cavitation.

March 21, 1932 (24 days)—Left chest opened Large caseous mass noted in lower lobe All pulmonary veins ligated

July 5, 1932 (130 days)—Animal killed Right (unoperated) side, cavity found in middle lobe Left (operated) side, scarred lesion found in lower lobe (Fig 1)

Dog No 21, March 25, 1932—One-quarter cc milky suspension deep into each main bronchus After three hours, all pulmonary veins on left ligated

July 6, 1932 (104 days)—Animal killed Right (unoperated) side, cavity found in lower lobe Left (operated) side, diffuse scarring in lower aspect of lower lobe (Fig 2)

Dog No 29, July 21, 1932—One cc milky suspension deep into each main bronchus

July 25, 1932 (four days)—All left pulmonary veins ligated



FIG 4—Dog No 30 (a) External appearance of lungs showing multiple discrete lesions in the unoperated lung (R)

September 7, 1932 (48 days)—Animal killed Right (unoperated) side, beginning cavitation in lower lobe Left (operated) side, scarring and caseation without beginning cavitation in lower lobe (Fig 3)

Dog No 30, July 21, 1932—One cc milky suspension deep into each main bronchus

July 25, 1932 (four days)—All left pulmonary veins ligated

September 7, 1932 (48 days)—Animal killed (was emaciated and hind legs paralyzed) Right (unoperated) side, clear-cut disseminated lesions chiefly in lower lobe Left (operated) side, more diffuse and less evident lesions in lower lobe (Fig 4)

Dog No 31, July 21, 1932—One cc milky suspension deep into each main bronchus

July 25, 1932 (four days)—All left pulmonary veins ligated

September 7, 1932 (48 days)—Animal killed Lesions found in right accessory and left lower lobe They did not differ greatly in appearance (Fig 5)

Dog A, January 11, 1933—All left pulmonary veins ligated

January 16, 1933 (five days)—One cc milky suspension (of a human culture from case of epididymitis) deep into each main bronchus

April 26, 1933 (100 days)—Animal killed Right (unoperated) side, cavity in lower lobe Left (operated) side, diffuse inconspicuous lesion in lower lobe Verified microscopically (Fig 6)

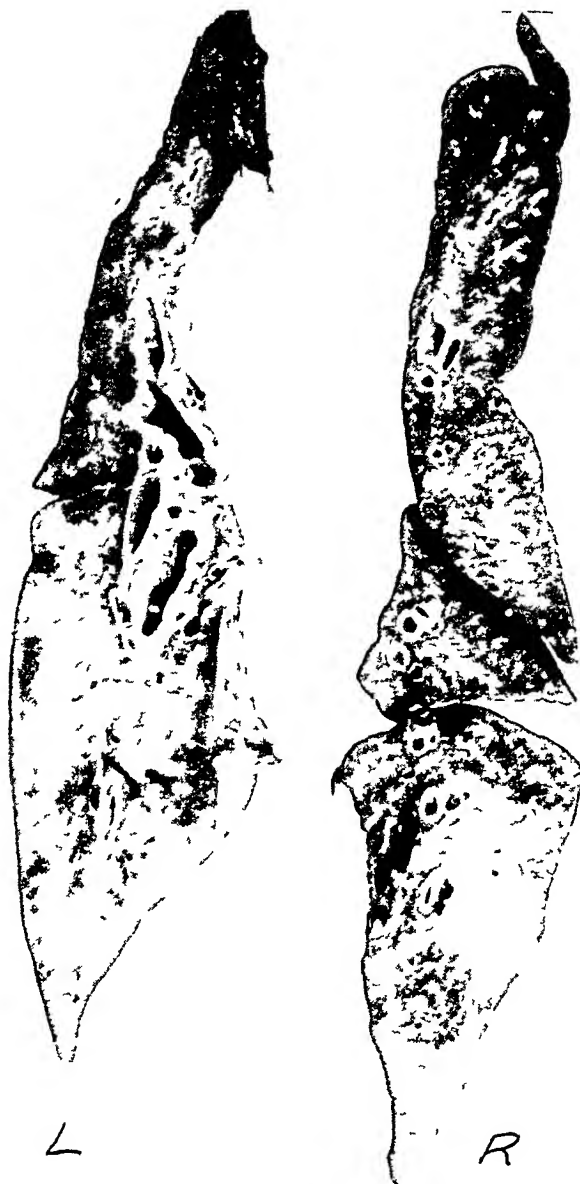


FIG 4 (b) —Cut surface of lungs showing discrete lesions in unoperated lung and more confluent but less evident lesions in the operated lung (I)

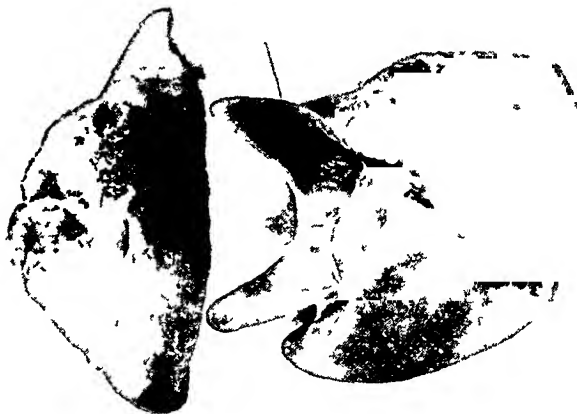


FIG 5 —Dog No 31 (a) External appearance of lungs showing lesions in right accessory and left lower lobes



FIG 5 (b) —Cut surface of lesions in operated lung (L) and unoperated lung (R) The lesions on the two sides do not differ greatly in appearance at this stage (48 days)

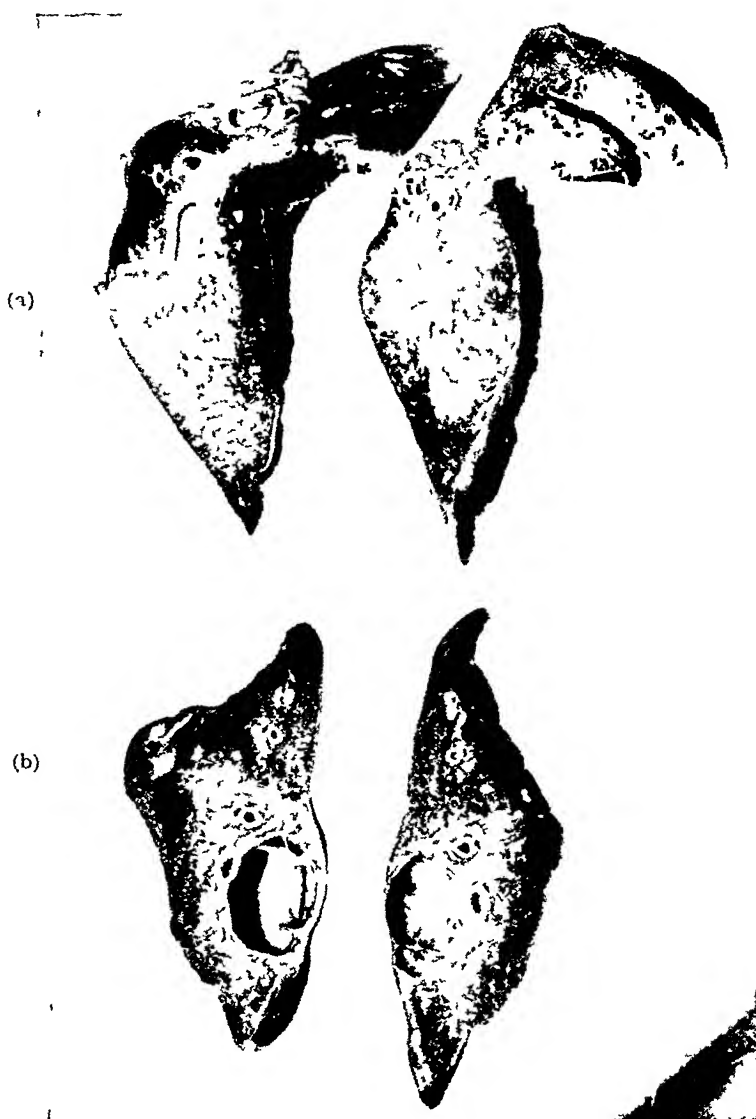


FIG 6 —Dog A (a) Mild, diffuse and inconspicuous lesion in operated lung, lower lobe (b) Cavity with obliterated vessels in unoperated lung, lower lobe

Dogs B and C—Same as for Dog A Lesion found in both lungs, not differing greatly on the two sides and without cavity formation

Dog D—Same as for Dog A This animal died 83 days following injection with overwhelming caseating lesions on both sides

Dog E, *January 16, 1933*—One cc milky suspension deep into each main bronchus
January 31, 1933 (15 days)—All left pulmonary veins ligated



FIG 7—Dog E Lesions in the lower lobes of both lungs, L operated and R unoperated

April 9, 1933 (83 days)—Animal killed Cavities in both lower lobes not differing greatly in appearance (Fig 7)

Dog F—Same as for Dog E Killed 100 days after injection Small lesions in both lungs not differing greatly in appearance and no cavities

Dog G, *January 25, 1933*—One and one-half cc milky suspension deep into each main bronchus

April 26, 1933 (91 days)—Animal killed Beginning cavitation in caseous lesion in both lower lobes Lesions did not differ in appearance (Fig 8)

SUMMARY—After endobronchial injections, lesions uniformly developed in the dependent parts of both lungs After 48 days the lesions were well ad-

vanced in the caseous stage. Cavitation was either just beginning or not present. At this stage, the lesion in the congested lung did not appear very different from that in the unoperated lung except in Dog No. 30. Here the lesions were scattered and appeared clean-cut and solitary on the unoperated side while on the congested side they were diffuse and more confluent.



FIG. 8—Dog G. Equivalent lesions with beginning cavitation in the lower lobes of both lungs. The pulmonary veins were not ligated in this animal.

Ligation of pulmonary veins was delayed in two dogs, 15 and 24 days after inoculation. In the first of these, 83 days later, cavity containing lesions appeared much the same in both lower lobes. In the second, 130 days later, a cavity was present on the unoperated and a scarred lesion on the operated side.

In five dogs the veins were ligated within five days of inoculation. (In one of these the veins were ligated before inoculation.) One died after 83 days of overwhelming caseous lesions on both sides. Two, after 100 days, presented caseous but healing lesions without cavitation and not differing on

the two sides Two dogs, after 100 and 104 days, presented a well formed cavity on the unoperated side and a scarred lesion on the operated side

One unoperated dog presented beginning cavitation in equivalent lesions on the two sides 91 days after inoculation

The only cavity that developed in a congested lung was in Dog E, in which the veins were ligated 15 days following inoculation On the other hand cavities developed in six unoperated lungs in this series

CONCLUSIONS

(1) The dog has a remarkable power of healing large endobronchial doses of human tubercle bacilli Advanced caseous lesions appear in 48 days, and in 100 to 130 days only benign appearing cavities remain, as a rule

(2) The manner in which equivalent lesions healed in the same dog differed notably in the congested and uncongested lungs

REFERENCES

- ¹ Hyndman, O R, and Landt, Harry Influence of Congestion on Tuberculosis Arch Surg, 28, 684-705, April, 1934
- ² Walsh, Groesbeck Ligation of the Pulmonary Vein, An Experimental Operative Procedure in the Treatment of Pulmonary Tuberculosis J A M A, 49, 1282, 1907
- ³ Fishberg, Maurice Pulmonary Tuberculosis 3d ed, Lea & Febiger, New York, 1922
- ⁴ Petit, Gabriel, and Panisset, Lucien Transmission de la Tuberculose aux grands et Petits Animaux par Inoculations Endobronchiques, suivant la Technique de Ph Kfoury Production Experimentale de lesions Tuberculeuses Exclusivement Pulmonaires, du Type clinique Humain La Presse Medicale, 1527-1530, December, 1927
- ⁵ Opie, E L Phthisiogenesis and Latent Tuberculous Injection Am Rev Tuberc, 6, 525-546, 1922
- ⁶ Livingston, H, and Hrdina, L C A Modified Meltzer Apparatus for Anaesthesia in Animals Jour Lab and Clin Med, St Louis, 16, No 1, 74, October, 1930

PERSISTENT SPINAL FLUID FISTULA DUE TO FOREIGN BODY

ASSOCIATED WITH STAB WOUND OF THE HEART WITH RECOVERY

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REVIEW of the readily available American literature reveals only three references to cerebrospinal fluid leakage caused by the presence of a foreign body Ball and Spurling¹ report an instance of a cerebrospinal fluid leak due to a fistula of the cisterna magna, caused by a stab wound in this region This patient drained 17 days On the twelfth day, a meningitis developed from which the patient recovered Shawan² reports a case of stab wound of the neck followed by leakage of cerebrospinal fluid, but without cord damage In this case, the causative knife blade was removed operatively and the patient recovered Rand and Patterson,³ in an extensive article on stab wounds of the spinal cord, report seven cases, only one of which showed drainage of cerebrospinal fluid and no case showed the presence of a foreign body Owen⁴ reports a case in which a foreign body was present but in which there was no fistula or cord injury resulting

In the foreign literature, Oith,⁵ and Mavrodin and Tzovaru⁶ report cases of wounds of the spinal cord with the drainage of spinal fluid

Case Report—Hosp No 109558 E N, colored, female, age 25, was admitted to the Harlem Hospital, August 8, 1938 She had been stabbed and slashed in the back of the neck, left face, left breast and left hand She was cold, perspiring profusely and in severe collapse, complaining of inability to move her extremities

Physical Examination—The essential stab wounds showed a one-half inch vertical laceration at the level of the third cervical spinous process just to the right of the mid-line There was a one-half inch laceration of the left breast in the lower outer quadrant, with the breast in the dependent position (Fig 1) This was in the anterior axillary line at the level of the fifth rib Five inches internal to this, at the margin of the sternum, there was tenderness on slight pressure Blood pressure 60/32, temperature 97.8° F, pulse imperceptible Auscultation of the heart revealed only an occasional audible beat She was immediately operated upon

Operation—Dr David H Smith Under general anesthesia, a flap of skin, subcutaneous tissue and muscle, extending from the second to seventh rib was reflected (Fig 1) The fourth and fifth costal cartilages and portions of the ribs were removed The internal mammary artery was then ligated The three-quarter inch vertical tear in the pericardium was enlarged to three and a half inches, exposing the heart There was noted a one-half inch transverse laceration of the left ventricle situated one inch above the apex This was oozing blood The under surface of the heart opposite this wound presented a one-quarter inch subpericardial hemorrhage The pericardial sac contained about 100 cc of blood The left pleural cavity contained about 300 cc of blood Three interrupted

Submitted for publication January 12, 1939

black silk sutures were used to approximate the wound of the anterior surface. These were left long and served as tractors, the heart not being manually handled. The heart was rotated by these sutures and a single silk suture used to bury the hemorrhagic area in the right ventricular wall. The pericardial wound was resutured leaving a gap of three-quarters of an inch for drainage into the left pleural cavity. The wound was closed in layers, the lung being sewn to the wound margins. A rubber dam drain was inserted just beneath the fat, at the lower angle of the wound.

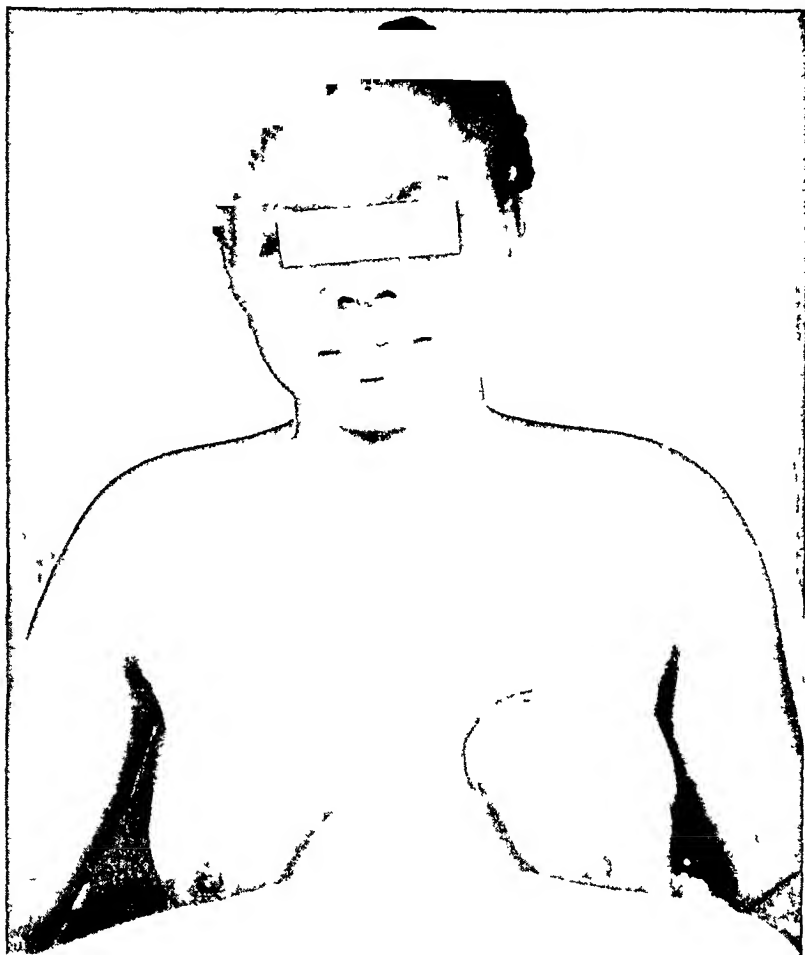


FIG. 1.—Showing the operative incision and scar. Breast shows the stab wound.

After the start of the operation the patient received 500 cc of 5 per cent glucose in saline followed by a 500 cc whole blood transfusion. A large bore needle was inserted into the left upper chest anteriorly in the second interspace to drain off excess air, and under water drainage was thus established. The operation consumed one hour and 15 minutes.

Postoperative Course—The first postoperative day, the patient received another transfusion of 500 cc. The blood pressure rose to 118/70. She was able to move her limbs slightly. The pneumothorax reading was -1, 0.

The second postoperative day, oral sulfanilamide therapy was started and she received 30 gr daily during the next 15 days. On the second day she received a 250 cc transfusion and was also taking fluids by mouth.

On the third postoperative day, the patient exhibited a paresis of the entire right side of the body with an absence of sensation in the right arm. The neck was discharging

SPINAL FLUID FISTULA

a pale, yellow, opalescent fluid which was grossly similar to spinal fluid. During the first week, this fluid continued to discharge from the neck. Its reaction was alkaline, and contained sugar 52 mg, sodium chloride 660 mg. The laboratory reported that the tests would indicate that this fluid was spinal fluid but due to the presence of blood this could not be determined with absolute certainty.

By the fourth postoperative day, the drainage of this fluid was very profuse. Smear showed polymorphonuclear leukocytes and gram-negative Bacilli. Culture showed *B. coli*. On several subsequent occasions this fluid showed cultures of *B. coli*.

During the first week the temperature fluctuated between 101° and 102° F.

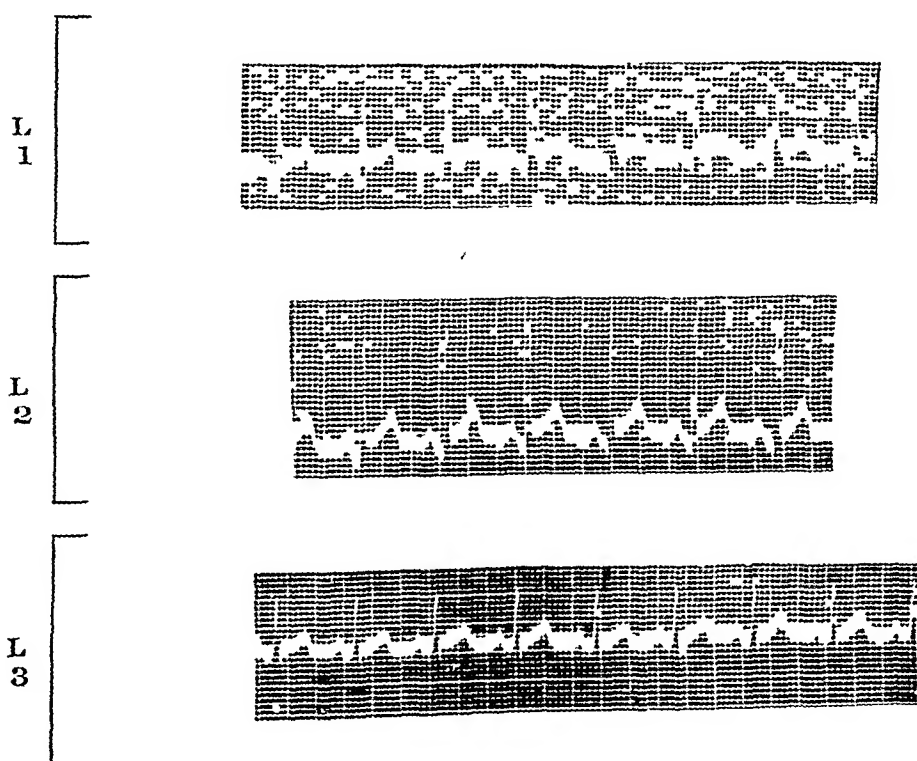


CHART 1—The electrocardiogram made on the day following operation showing high ST take off in Leads 1 and 2

The electrocardiogram, the day following operation (Chart 1), showed high ST take-off in Leads 1 and 2, indicating coronary changes. One week later, the EKG showed sinus rhythm and no evidence of injury to the pericardium or myocardium (Chart 2). Two subsequent, weekly EKG's showed no abnormality, yet another, taken six weeks after the injury (Chart 3), showed in Lead 1, a prominent P wave and a slurred R wave. Leads 2 and 3 showed inverted T waves, indicating myocardial damage.

Roentgenologic examination of the chest immediately postoperative showed a pneumothorax on the left side with partial collapse of the lung.

Further progress was satisfactory except for a paresis of the right arm.

Spinal tap was first done two weeks after injury. The fluid was clear. The cell count was eight lymphocytes and the pressure 150 Mm. The tap was done because of headache and a persistently rigid neck. Roentgenograms of the cervical region, on several occasions, were unsatisfactory because of difficulty in getting the patient into good position.

Four weeks after operation, the patient was out of bed in a wheel chair. She was allowed up each day in the chair for the next ten days. At the expiration of this time, her progress was so marked that she was allowed to walk about ten feet. She then was returned to bed. Fifteen minutes later, she complained to the nurse that she was unable to move her arm or legs.

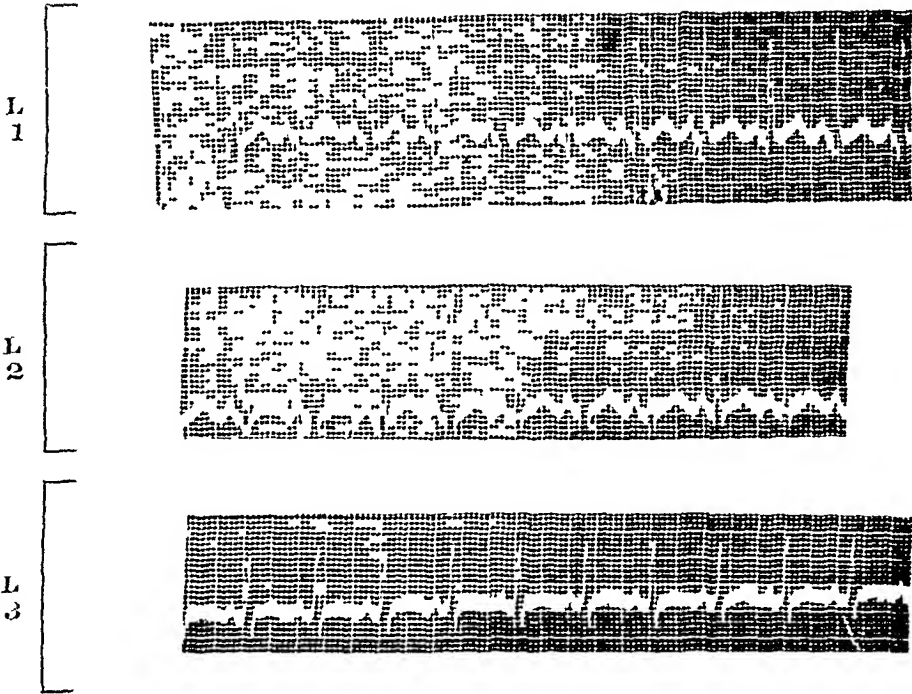


CHART 2—An electrocardiogram made one week following operation

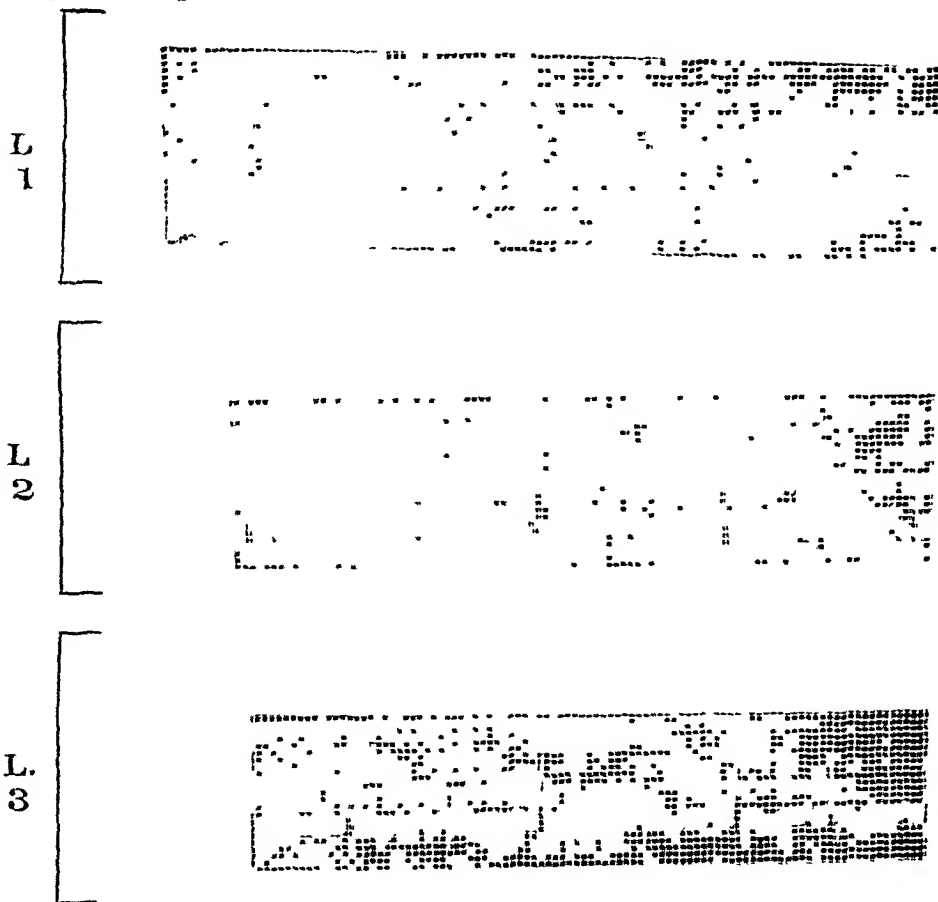


CHART 3—An electrocardiogram made six weeks after injury, with Lead 1 showing prominent P and slurred R. Leads 2 and 3 show an inverted T wave

SPINAL FLUID FISTULA

Neurologic examination showed loss of sensation from the clavicles down. There was loss of sphincteric control (both urine and feces) and complete loss of motion of the extremities with the exception of the left arm, which was paretic. The right biceps reflex was absent. All other deep reflexes were hyperactive. There were bilateral ankle clonus and bilateral Babinski signs. Rigidity of the neck was marked. There was bilateral papilledema amounting to four diopters. It was felt there was a root



FIG 2—Roentgenograms showing (A) and (B) different aspects of the knife blade in the cervical cord

lesion at C5 or 6, right side. Spinal tap was again performed. The fluid was clear and showed five lymphocytes, pressure 415 Mm. Kahn negative. Colloidal gold showed no abnormality. The Queckenstedt was negative.

Because of the cord symptoms, the neck was again roentgenographed. A broken knife blade was visualized, apparently between the third and fourth cervical vertebrae (Fig 2, A and B).

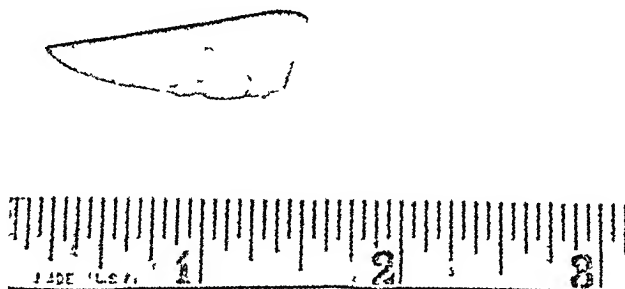


FIG 3—Photograph of knife blade extracted

Forty-six days after the initial injury, the patient was reoperated upon. A midline posterior cervical incision was made under local anesthesia (1 per cent novocain) and the tissues incised down to the bodies of the vertebrae. A sinus tract led down to the third cervical vertebra through which the spinal fluid had ceased to drain three weeks previously. After a tedious search, the knife blade was finally discovered, a distance of about one and one-quarter inches, between the bodies of the third and fourth cervical vertebrae, right side. It protruded about one-quarter inch into the spinal canal (Fig 3). There was no leakage of spinal fluid. Culture of the tissues later showed *Staphylococcus albus*. The wound was lightly packed with iodoform gauze. The operation took one hour and 40 minutes.

Three days following this operation, muscle strength began to return. There was also a desire to urinate. But the papilledema did not subside.

Two months following this second operation, motor power of all the extremities was very good. However, there was occasional urinary incontinence and some difficulty in supporting the body weight. The thoracic incision had completely healed and there was no abnormal pulsation in the precordial area.

COMMENT—(1) This case is unusual in that there was present a fistula of spinal fluid which drained from the open dura in the cervical portion of the canal for 25 days. And yet, even in the presence of a foreign body, infection of the meninges did not occur.

(2) Because meningitis commonly complicates spinal cord injuries of the above type, and because suppurative pericarditis is often the lethal factor following stab wounds of the heart, it is strongly recommended that sulfanilamide be given in these cases.

REFERENCES

- ¹ Ball and Spurling. *Annals of Surgery*, 85, 31, January, 1927.
- ² Shawan, H. K. *JAMA*, 95, 1671, November 29, 1930.
- ³ Rand, C. W. and Patterson, G. H. *Surg, Gynec and Obstet*, 48, 652, May, 1929.
- ⁴ Owen, W. B. *Int Jour Surg*, 30, 244, 1917.
- ⁵ Orth, O. *Zentralbl f Chir*, 63, 868, April 11, 1936.
- ⁶ Mavrodin and Tzovaru. *Spitalul*, 48, 17, January, 1928.

DUODENOJEJUNOSTOMY FOR CONGENITAL, INTRINSIC, TOTAL ATRESIA AT THE DUODENOJEJUNAL JUNCTION

SUCCESSFUL RESULT IN A THREE-DAY-OLD, ONE-MONTH-PREATURE INFANT
WEIGHING FOUR POUNDS TWO OUNCES

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CONGENITAL OBSTRUCTIONS of the upper intestinal tract have been recognized since Calder's¹ first report, in 1733, but apparently the diagnosis was usually overlooked or, if made, the treatment was unsuccessful, because, as late as 1922, Davis and Poynter² reported on 392 cases of congenital intestinal occlusions of all parts of the intestinal tract above the anus, collected from the literature, either autopsy or operative findings, with only two recoveries after entero-enterostomy—a mortality of nearly 99.5 per cent. The first recovery in a case of atresia of the lower ileum is credited to Fockens,³ in 1911, and the second in a case of atresia of the second portion of the duodenum below the papilla to Einst,⁴ in 1916. They also showed that the condition is not exceptionally rare, because they estimated that it occurred about once in 20,000 infants, and that in 15 per cent the atresias are multiple and more or less beyond the aid of surgery. Quite a number of operative successes in high occlusions have been reported since Fockens' first case, notably by Ladd,⁵ Morton and Jones,⁶ and McIntosh and Donovan,⁷ all of whom have reported on multiple experiences, with a large proportion of satisfactory results and a gradually increasing reduction of the postoperative death rate. Stenson⁸ has also recently reported an operative success in a case of extrinsic duodenal atresia occurring in a premature twin. To these I wish to add the appended successful operative result in a case of intrinsic total atresia at the duodenojejunal junction. As far as a rather careful search of the literature reveals, the patient is the youngest one—also taking into consideration his one month's prematurity—which has recovered.

Case Report—E. H., white, male, age three days, was born March 29, 1938, at Lenox Hill Hospital. It was the first child and one month premature. Weight at birth four pounds 11 ounces. It did not retain any feedings and vomited bile-stained material from birth, and had passed only a few meconium stools. It became increasingly jaundiced and had lost nine ounces when first seen by the author in consultation with Dr. Jerome S. Leopold, April 1, 1938, when it was three days old.

Physical Examination—The child was a very small, feeble, emaciated, deeply jaundiced, quite dehydrated infant weighing four pounds two ounces. The abdomen was somewhat distended. There was a decidedly dilated stomach, with visible gastric peristalsis, and an indefinite sausage-like mass could be palpated running obliquely from the right upper to the left lower quadrant. Roentgenologic examination of the alimentary

* Presented before the Joint Meeting of the New York Surgical Society and the Philadelphia Academy of Surgery, New York, N. Y., February 8, 1939. Submitted for publication April 18, 1939.

tract showed a normal esophagus, a considerably dilated stomach with active peristalsis, a wide open pylorus, and a tremendously distended duodenum with a complete obstruction at what appeared to be the duodenojejunal junction. There was absolutely no passage of barium beyond the point of obstruction after three and one-half hours (Fig 1). The blood count showed 170 per cent hemoglobin and 5,500,000 red blood cells—the result of the dehydration.

Operation—April 1, 1938. Dr. DeWitt Stetten. Preoperative gastric lavage. Under

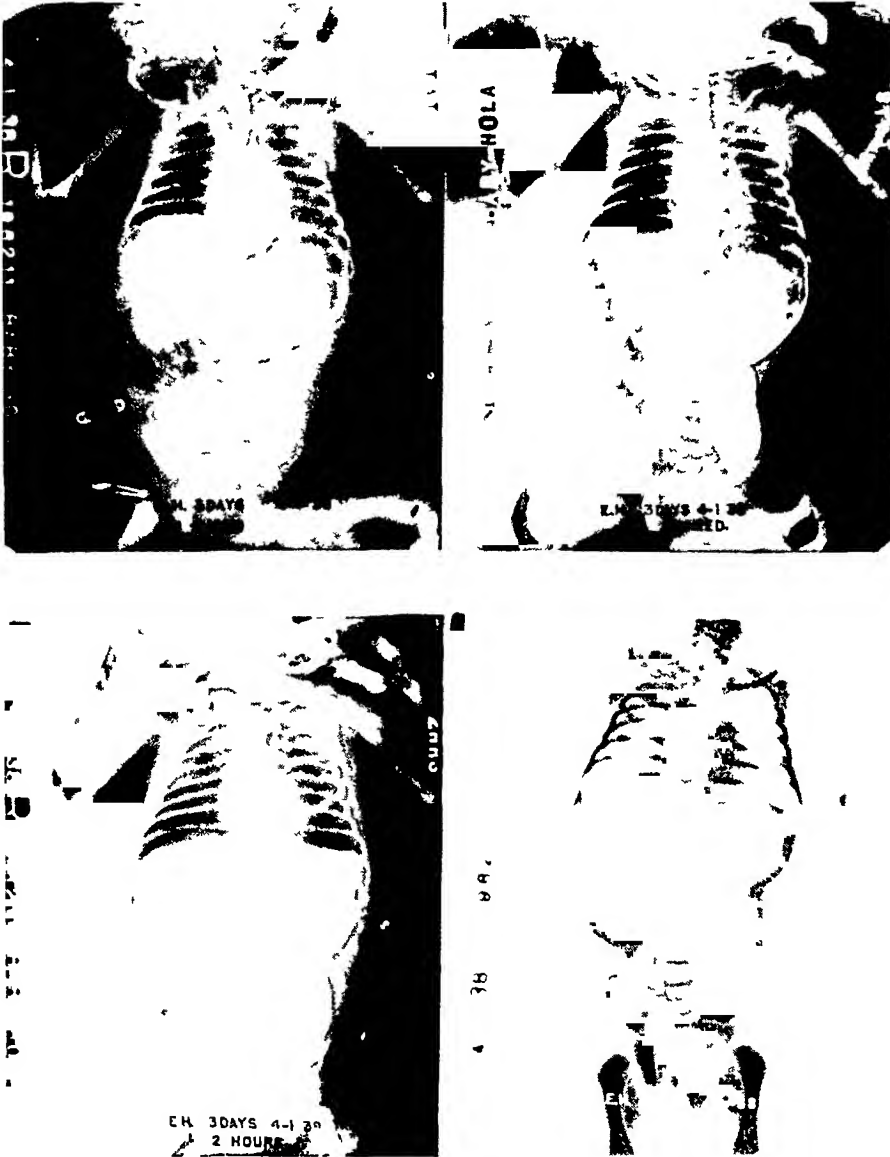


FIG 1—Preoperative gastro intestinal roentgenographic series showing normal esophagus, considerably dilated stomach, with active peristaltic changes, wide open pylorus, tremendously distended duodenum, complete obstruction at duodenojejunal junction, and absolutely no passage of barium beyond point of obstruction after three and one half hours.

ether-drop anesthesia the abdomen was opened through a median epigastric incision extending below the umbilicus. There was a moderate amount of slightly sanguineous, bile-stained, serous fluid in the abdominal cavity. *Operative Pathology* A considerably dilated, somewhat thickened stomach was found with a wide open pylorus from which ran a huge, tensely distended, markedly injected, sausage-shaped duodenum of a yellowish-

pink color, occupying a good part of the abdomen. It was about one and one-quarter inches in diameter and ran from the right upper to the left lower quadrant. It was apparently entirely intraperitoneal, with a distinct mesentery. The wall was definitely thickened. The distended duodenum terminated abruptly, closed by a total, intrinsic diaphragmatic atresia, and continued in a much contracted, thin-walled jejunum which was not much more than one-eighth of an inch in diameter, about the size of the bulb of a mouth thermometer. The balance of the small and large intestine was crowded over to the left side of the abdomen, and the ileocecal junction, with a tiny appendix and a rather



FIG 2.—Drawing showing findings at operation and operative procedure. Note the dilated stomach with wide open pylorus and huge distended intraperitoneal duodenum with total intrinsic diaphragmatic atresia at duodenojejunal junction, much contracted jejunum and ileum, arrested rotation of cecum, and duodenojejunostomy at lowest point of obstructed duodenal loop.

primitive cecum, lay in the angle formed by the stomach joining the duodenum—indicating an arrested rotation of the colon (Fig 2). The patency of the jejunum below the obstruction was tested and, incidentally, the lumen of the much contracted intestine was widened slightly by the injection of saline solution through a hypodermic syringe, as suggested first by Clogg⁹ and, subsequently, by Webb and Wangenstein¹⁰. On finding the lumen patent, a typical lateral, quite satisfactory antiperistaltic duodenojejunostomy, about five-eighths of an inch in length, was made, employing a double row of very fine, continuous silk sutures at the lowest possible point of the duodenal loop, without the use of clamps. When the duodenum was opened the bile-stained barium and food residue spurting out under marked pressure. There was some difficulty in making the anastomosis and preserving the jejunal lumen because of the extreme disproportion between the size of the duodenum and the jejunum, and also because of the marked difference in the thickness of the walls of the two sections of the intestine. To give a practical illustration of the technical problem involved, the procedure might be compared to the establishment of a lateral anastomosis between a normal adult jejunum and an average-sized median cephalic vein. The abdominal wall was closed in the usual manner in three layers with through-and-through silk sutures through the skin and fascia.

Postoperative Course—The child was put on feedings of breast milk, placed in an incubator, given a small citrate transfusion and repeated clyses. The operation was very well borne by the infant, and there was only a slight rise of temperature to 101.4°F 12 hours after operation. This, however, immediately dropped to normal and remained there. Three days after the operation, the baby had several small, loose, yellow stools containing barium, bile and milk curds. The jaundice, probably obstructive in character and due to an edema at the papilla, rapidly disappeared but vomiting persisted. That is the usual experience in these cases as compared with the immediate disappearance of vomiting which regularly follows the successful operation for congenital hypertrophic pyloric stenosis (Fig 3).

The vomiting continued and was treated by gastric lavage. There was a tendency



FIG 3—Photograph of patient one week after operation



FIG 4—Photograph of patient at eight and one half months of age

toward loose and frequent bowel movements. The child's weight fluctuated between four pounds four ounces and four pounds nine ounces. Another transfusion was given. Two weeks after the operation, Dr Edward J. Donovan was good enough to see the case in consultation, as I was getting somewhat disheartened because of the persistent vomiting. He advised a continuation of the gastric lavage with an attempt to evacuate the, probably, distended duodenal loop, and felt that the vomiting might be due, mainly, to the partial closure of the stoma because of an edema of the duodenal loop at the site of the anastomosis. A few days later the vomiting stopped and then the baby began to develop a rather intractable diarrhea which at first was thought to be due to a lack of development of the mucosa of the ileum and its lacteals, analogous to the diarrhea from the mucosal atrophy occurring in sprue. The diarrhea was, however, eventually controlled by changing the diet from breast to protein milk.

Subsequent Course—The wound healed *per primam* but a small hernia developed to the right of the scar near the upper angle, apparently due to one of the cutaneous-fascial silk sutures cutting through the fascia. The child was kept in the incubator for five weeks. Two more blood transfusions were administered, and clyses, twice daily, were continued until the diarrhea was controlled, when the baby weighed five pounds four ounces. From then on, the recovery was uneventful, with a gradual increase in weight until the child's discharge from the hospital, June 26, 1938 at the age of three months,

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when its weight was seven pounds two ounces. I feel that the successful result was in a great measure due to the optimistic and devoted care given to the patient by the nurses in charge. Since the child has been under the very excellent and intelligent care of its mother at home, capably directed by Dr Irwin P. Sobel, it has done remarkably well.

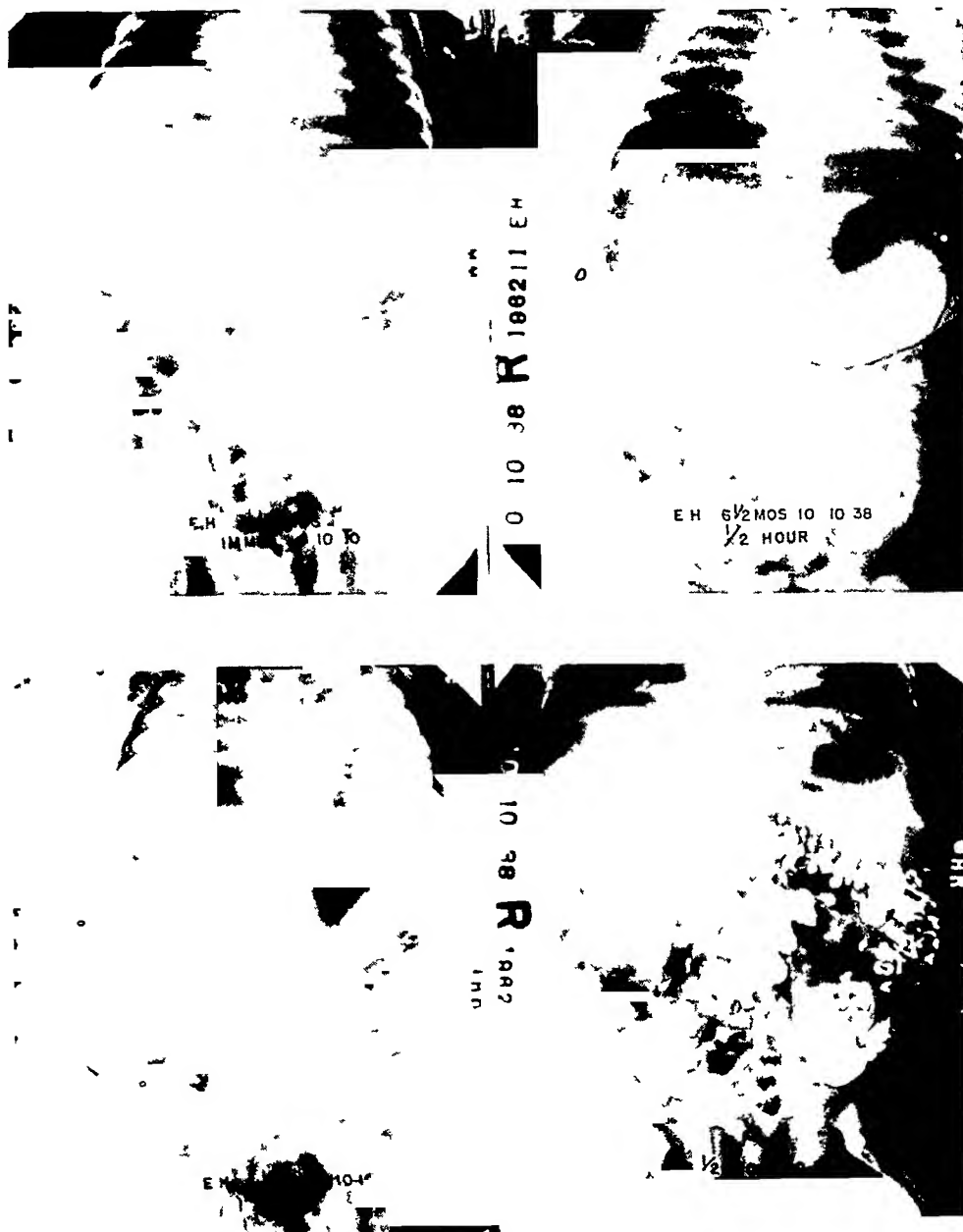


FIG 5—Postoperative gastro intestinal roentgenographic series at age of six and one half months showing still somewhat dilated stomach, satisfactorily functioning anastomosis, and persistent distention of duodenal loop with almost complete emptying of stomach in one hour and some retention of barium in distended duodenum with a trace in stomach after six hours and with most of barium in colon, head of meal being in distal portion of descending colon. Note the abnormal position of the cecum near the midline with ascending colon rising therefrom and balance of colon in left side of abdominal cavity.

and has been gaining weight by leaps and bounds. The baby is on the usual mixed diet for a child of its age. It has a hearty appetite, never vomits and seems to have an excellent digestion. Except for a recent, slight, transitory diarrhea, due to some dietary irregularity, the bowels have been regular with perfectly normal stools. The child's mental development, at first, seemed rather slow but gradually it began to progress quite normally (Fig 4).

A postoperative roentgenologic check-up, October 10, 1938, when the child was six and one-half months old, shows that the stomach, although still somewhat dilated, empties almost completely in one hour, the anastomosis seems to function very well, although the duodenal loop is still quite distended and there is some barium retention in this loop, with a trace still in the stomach at the end of six hours, but most of the barium is in the colon, the head of the meal being in the distal portion of the descending colon. The abnormal position of the cecum is well demonstrated near the midline from which the ascending colon rises, the balance of the colon being in the left side of the abdominal cavity (Fig 5). The persistence of the dilatation of the duodenal loop, which is known to occur without symptoms in these cases, is apparently causing no disturbance.

Follow-Up—January 13, 1940. The child is now almost one year and nine and one-half months old. He is unusually husky, is in excellent health and has a perfect digestion with normal stools. He has been walking alone and talking since July, 1939, when he was one year and three months old. He is most wide-awake and has cut 16 teeth, the correct number for a child two years of age. His weight is 28 pounds two ounces and his height 33 inches—at least two pounds above the average weight and approximately the average height for his age. The small ventral hernia has almost entirely disappeared.

While the pathologic conditions found in these cases vary greatly, whether the lesions are intrinsic or extrinsic, as classified by Ladd, all have, in common, the almost immediate signs of high obstruction from birth—the persistent vomiting which is bile-stained if the lesion is below the papilla, as is generally the case, no bowel movements or only meconium stools, and rapid loss of weight and dehydration. There is usually a dilated stomach and the diagnosis is generally settled by characteristic roentgenologic findings. The vast majority are either associated with, or directly caused by, a particular developmental anomaly, namely, incomplete or abnormal rotation of the midgut.

As regards treatment, all the cases also have in common the imperative necessity for the earliest possible surgical intervention. As far as the procedure which is indicated is concerned, that will, of course, depend entirely upon the findings. Each case must, naturally, be judged on its own merits, but, in general, it can be said that the operation should be the simplest that can be performed to relieve the obstruction—separation of obstructing bands or reduction of an internal hernia, or if necessary for a true atresia or an irreducible obstruction, an entero-enterostomy. A gastroduodenostomy or a gastrojejunostomy is indicated only, of course, if the obstruction is above the papilla. Resection or ileostomy is contraindicated, as they have an almost 100 per cent mortality.

The extensive diagnostic and surgical experience gained in recent years from the very much simpler problem of congenital hypertrophic pyloric stenosis and the almost 100 per cent success with the standardized method of treatment—the Rammstedt operation—in these cases has, I believe, been largely responsible for the increasing number of correct diagnoses and successful operative results in this other much more complicated and serious condition. We have learned much about the exact, painstaking operative technic necessary in handling the small organs and delicate tissues of the newborn, and the correct methods of anesthesia. We have also learned

that if properly handled the newborn infant has an extraordinary tolerance toward a major operative procedure. This has encouraged us to operate as soon as possible and the perfection of roentgenologic technic has helped us in the early diagnosis. The pediatricians, who have stood by us loyally in all these cases, have taught us much about preoperative preparation and the counteracting of dehydration by clyses and transfusions and also about postoperative supportive treatment, with the continuation of clyses and transfusions, proper nursing and feeding with breast milk or carefully prepared formulae and modern incubation. As a result, we now feel that even very feeble, small, premature infants, if properly prepared, can be successfully operated upon, even within the first few days of their life.

REFERENCES

- ¹ Calder, James, Jr. Two Examples of Children Born with Preternatural Conformations of the Guts. *Medical Essays and Observations*, Edinburgh, 1, 203-206, 1733
- ² Davis, Delmer L., and Poynter, C. W. M. Congenital Occlusions of the Intestines with Report of a Case of Multiple Atresia of the Jejunum. *Surg., Gynec. and Obstet.*, 34, 35-41, January, 1922
- ³ Fockens, P. Ein operativ geheilter Fall von kongenitaler Duodarmatresie. *Zentralbl. f. Chir.*, 38, 532-535, April 15, 1911
Idem. Over aangeboren atresie van den darm, net een door operatie genezen geval. *Nederlandsch Tijdschr. v. Geneesk.*, 47, IB 2 reeks 1658-1665, May 6, 1911
- ⁴ Ernst, N. P. A Case of Congenital Atresia of the Duodenum Treated Successfully by Operation. *Brit. Med. Jour.*, 1, 644-645, May 6, 1916
- ⁵ Ladd, William E. Congenital Obstruction of the Small Intestine. *J. A. M. A.*, 19, 1453-1458, November 4, 1933
Idem. Congenital Duodenal Obstruction. *Surgery*, 1, 878-885, June, 1937
- ⁶ Morton, John J., and Jones, T. Banford. Obstructions About the Mesentery in Infants. *ANNALS OF SURGERY*, 104, 864-891, November, 1936
Idem. Congenital Malformation of the Intestine in Children. *Am. Jour. Surg.*, 39, 382-399, February, 1938
- ⁷ Donovan, Edward J. Congenital Atresia of Duodenum in Newborn. Duodenojejunostomy. *ANNALS OF SURGERY*, 103, 455-457, March, 1936
McIntosh, Rustin, and Donovan, Edward J. Disturbances of Rotation of the Intestinal Tract. *Am. Jour. Dis. Child.*, 57, 116-165, January, 1939
- ⁸ Stenson, Walter. Duodenal Occlusion in the Newborn. Successful Operation on a Premature Twin. *Am. Jour. Dis. Child.*, 56, 1066-1081, November, 1938
- ⁹ Clogg, H. S. Congenital Intestinal Atresia. *Lancet*, 2, 1770-1774, December 24, 1904
- ¹⁰ Webb, C. H., and Wangenstein, Owen H. Congenital Intestinal Atresia. *Am. Jour. Dis. Child.*, 41, 262-284, February, 1931

DISCUSSION DR. WALTER ESTELL LEE (Philadelphia).—Interest in congenital obstructions of the small intestine has been stimulated in recent years by the pediatricians who have been diagnosing the condition correctly with increasing frequency. The improvement in the surgical management of intestinal obstruction and the advances in the surgery of the gastro-intestinal tract applied to infants have abetted this new interest by affording more hopeful prognoses in these cases. Fortunately the incidence of these cases is not great. Krieg quotes a series of 688,992 consecutive newborn infants collected by E. Theremin, De Sanctis and Craig, Thorndike, and von Kloos, in which there occurred only 31 instances of intrinsic deformities of the duodenum—an incidence of one in 21,580. Without offering any original

contributions to the problem, we feel that it may be worth while reporting two cases which we have encountered because of several unusual features which they demonstrate

To quote again the frequently repeated statement of J Bland Sutton "Congenital obstruction and narrowing of the alimentary canal are always found in the situation of embryologic events" The situations of these embryologic events, in the small bowel, are the regions of the ampulla of Vater and the site of attachment of the omphalomesenteric duct It is the former region with which we are concerned in the cases to be presented

In the normal embryologic development the lumen of the small intestine is round and lined with epithelium up to the fifth week of life By a proliferation of this epithelium the lumen is obliterated soon thereafter However, by the twelfth week, the lumen is again reestablished by a process of vacuolization of the epithelial cells Because of the growth of the liver and pancreas from the duodenum this normal process of recanalization of the bowel is sometimes interrupted in varying degrees, and stenosis or atresia or a membranous diaphragm may result

Forssner's classification of these abnormalities is simple and includes the major possible abnormalities There may be a diaphragm, complete or incomplete, a stenosis, complete or incomplete, or an atresia with the occluded ends either separated or connected by a fibrous cord It is impossible to differentiate these conditions preoperatively except to the extent of recognizing that the obstruction is complete or incomplete

The characteristic symptom of this condition is vomiting which varies in time of onset and severity with the degree of the obstruction In a case of complete obstruction the vomiting usually begins by the second day and always by the fifth day The presence of bile in the vomitus is not of special significance because the obstruction may be above or below the ampulla of Vater In several reported cases there was bile in both the vomitus and the stools due to the opening of an accessory bile duct below the level of the obstruction There is usually definite evidence of pain or discomfort Absence of stools is the rule

The patient is usually distended and shows signs of dehydration and malnutrition after a few days from the onset of the obstruction Visible peristalsis may be present but is not conclusive There is frequently a palpable tumor in the right upper quadrant of the abdomen due to the distention of the duodenum Roentgenologic studies with a barium meal show the stomach normal or dilated, a patent pylorus, and a dilated duodenum proximal to the point of obstruction In incomplete obstruction small amounts of barium are seen in the small intestine distal to the lesion

Surgical intervention is necessary to cure cases of intrinsic duodenal obstruction Since it is usually impossible to detect the site of the lesion by examination of the serosal surface of the bowel, the affected area must be short-circuited by an anastomosis According to the prevailing opinion the most efficient type of anastomosis is a duodenojejunostomy This type of operation, employing a single row of fine arterial silk sutures, is the one used so successfully by Ladd Gastrojejunostomy is frequently more practical, technically, and has been successful in a fair number of cases Morton was able to localize a congenital diaphragm in one case and excise it with the electric knife Various details of technic, such as the type of suture material best suited for the anastomosis, and the dilatation of the collapsed bowel distal to the obstruction preliminary to performing the anastomosis, have been emphasized by various authorities on the subject

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One rule that seems to be held unanimously is that a simple jejunostomy is palliative for a short time only and is later followed by death of the patient. In all the cases so treated, except the one reported by Ladd, the patients have died following a simple enterostomy. In view of this fact it is interesting that one of our cases, herewith recorded, recovered and developed normally for a period of eight months following jejunostomy.

CASE REPORTS

Case 1—Baby U, a white, female infant, was delivered by low forceps from a primiparous mother, March 3, 1936. The delivery was uncomplicated except for slight asphyxia, due to mucus in the posterior pharynx, which was relieved promptly by aspiration. The birth weight was six pounds ten ounces. On the second day after delivery, projectile vomiting began and continued with increasing severity during the third and fourth days. The stools consisted of meconium only.

FIG 1



FIG 2

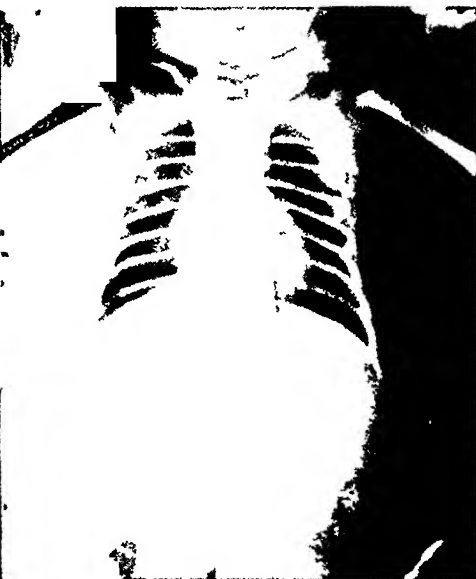


FIG 1—Four days after birth. Almost complete obstruction to the duodenum.
FIG 2—March 11, 1936. Major portion of barium meal still in stomach and duodenum after 12 hours. A few scattered flakes of barium in the small and large intestines indicate that the obstruction is not complete.

Physical Examination—The abdomen, on the fourth day after birth, showed moderate distention with peristaltic waves passing across it from left to right and occasionally in the reverse direction. The infant was in good condition and not dehydrated, having received adequate amounts of fluids parenterally. A barium meal, administered through a catheter, remained in the stomach and in the dilated proximal duodenum. After one hour no barium had passed beyond the first portion of the duodenum (Fig 1).

Operation—March 7, 1936. Dr. Walter E. Lee. Numerous adhesions were found extending from the pyloric end of the stomach and duodenum to the gallbladder and liver, which caused constriction of the first portion of the duodenum. These adhesions were separated, and since the child's condition was not good the abdomen was closed without further exploration. Three hours after operation mouth feedings of Downe's formula were instituted and supplemented by infusions of Hartman's lactated Ringer's solution.

An upper respiratory infection occurred during the next three days which was feared to have developed into a bronchopneumonia. A roentgenogram showed diminished aeration at the apex of the right lung but no evidence of consolidation. A more interesting roentgenologic finding was the presence of the major portion of the barium,

administered four days previously, in the stomach and first portion of the duodenum. A few scattered flecks of barium in the small and large intestine indicated that the obstruction was not complete (Fig 2)



FIG 3—November, 1936 Showing normal physical condition after eight months of jejunal feeding

FIG 4

FIG 5



FIG 4—Roentgenogram taken eight months after jejunostomy showing almost complete obstruction of duodenum after the injection of a barium meal

FIG 5—June 10 1938 Roentgenogram taken 19 months after a posterior gastrojejunostomy

The infant was fortified by a transfusion and by infusions of fluids, and a second celiotomy was performed by Doctor Lee, March 12, 1936. Additional adhesions were found about the duodenum as well as an obstruction of the duodenum in its second por-

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tion Because of the patient's critical condition it was thought best to perform as little surgery as possible Therefore, a simple jejunostomy was performed

Mouth feedings were carried out for the ensuing 24 hours, but were promptly vomited On the second day postoperatively, feedings of small amounts of 5 per cent glucose solution in normal saline were administered through the enterostomy tube Gradually, the mouth feedings were diminished and the tube feedings increased, until two weeks postoperatively, when adequate amounts of breast milk were being given by tube Later, as the mother's milk diminished, peptonized milk was used as a substitute Frequent small transfusions were administered during this period and the child gained weight and strength The operative wound healed completely except for the jejunostomy opening which admitted a No 8 Fr catheter

During the fifth and sixth months postoperatively, the infant's weight remained stationary at 12 pounds At the end of the seventh month the weight had increased to 14 pounds (Fig 3) Roentgenologic examination, however, showed practically a complete obstruction of the duodenum to be still present (Fig 4)

FIG 6

FIG 7

FIG 8



FIG 6—May 1, 1938 Roentgenogram taken three days after birth shows an abnormal distention of the stomach and duodenum with air

FIG 7—May 2, 1938 Roentgenogram taken four days after birth shows almost complete obstruction to the passage of a barium meal in the second portion of the duodenum

FIG 8—June 14, 1939 Roentgenogram taken 33 days after an anterior gastrojejunostomy

November 10, 1936 Eight months after the original operations, a third celiotomy and posterior gastro-enterostomy, using silk sutures, were performed by Doctor Lee Following the operation, tube feedings were carried on as usual for one week and then gradually diminished while mouth feedings were instituted At the end of the second week postoperatively all nourishment was administered by mouth

Subsequent Course—The child showed a progressive increase in weight and has not vomited since the last operation The jejunostomy persisted for six weeks but was finally closed by constant plugging of its orifice and by approximating the skin edges Roentgenologic studies, June 10, 1938, showed that the gastro-enterostomy was functioning perfectly (Fig 5)

At the present time, January, 1939, the child is normal in both weight and development

Case 2—Baby H, a white, male child, was delivered spontaneously, May 1, 1938, from a healthy mother, who had one older child living and well The birth weight was six pounds one ounce There were no external abnormalities Soon after birth the child began to have attacks of cyanosis followed and relieved by the eructation of mucus On

the second day after birth, these eructations became more frequent, and after taking water by mouth there was bright red blood in the vomitus. The infant grew quite listless, and had an almost continuous stream of fluid coming from both nose and mouth. Nothing taken by mouth was retained.

On the third day after birth, a roentgenogram of the chest showed evidence of incomplete expansion or possibly bronchopneumonia in both lungs. Fluoroscopic and film examinations with barium in the esophagus showed no abnormality in swallowing.

Mouth feedings were stopped on the third day and glucose and normal saline solutions were administered hypodermically. Regurgitation of everything taken by mouth, in the form of a brownish liquid, continued on the fourth day. There had been no stools. Roentgenologic examination of the abdomen revealed the following information: There were two large pockets of air in the epigastrium divided by a narrow line, the left pocket being larger than the right (Fig. 6). A portion of the barium given 24 hours previously had been regurgitated but most of it was trapped in the two air pockets, flowing freely between them. A small portion of the barium had reached the small intestine (Fig. 7). The conclusion was that a high obstruction existed, probably in the duodenum.

Operation—May 5, 1938. An exploratory celiotomy was performed by Doctor Lee. The stomach, and first and second portions of the duodenum were markedly distended. The pylorus was dilated but not hypertrophied. The obstruction was probably in the retroperitoneal portion of the duodenum. An anterior gastrojejunostomy was performed and the abdomen closed.

During the first three days postoperatively, the infant had a temperature ranging from 100° to 102° F. This, however, subsided on the sixth day. Transfusions and parenteral fluids only were administered until the second day, when small amounts of water were given by mouth. On the third day diluted breast milk was given successfully.

The first small meconium stool was passed on the second day postoperatively, while on the fifth day the stools contained bile and milk curds.

The child showed a slow but continuous gain in weight from May 9, the fourth day postoperatively, until June 25, when he weighed seven pounds 11 ounces on discharge from the hospital. Regurgitation of small amounts of bile-stained fluid after each feeding began about one week after operation and continued throughout his hospital stay. This phenomenon is still going on, although intermittently, and the amounts of fluid regurgitated are small.

Follow-Up—June 14, 1938. A roentgenologic study showed the gastroenterostomy functioning well. More than one-half the barium meal had left the stomach at the end of one and three-quarters hours. The first portion of the duodenum remained dilated, and no barium was seen leaving the duodenum in the normal manner (Fig. 8).

Discussion—It is interesting that in the second case the primary difficulty was thought to be in the chest and, indeed, the roentgenograms of the chest were helpful in directing attention to the real source of trouble. A correct diagnosis of obstruction of the duodenum was then made. This same sequence of events occurred in an infant recently treated at the Children's Hospital of Philadelphia. It leads one to speculate about the possible origin of the pulmonary condition from compression due to the distended stomach and duodenum.

The incompleteness of the obstructions was demonstrated by the presence, in both patients, of small amounts of barium distal to the sites of obstruction. Therefore, we realized that the pathology was not that of atresias, but either incomplete diaphragms or stenoses which caused partial blocking of the lumina. Both cases illustrate the usual difficulty experienced in determining the nature of the lesion as well as its exact location by examination of the external surface of the bowel.

The first infant is remarkable in that she survived a period of eight

CONGENITAL ATRESIA OF INTESTINE

months' feeding via an enterostomy tube. This jejunostomy was performed despite the knowledge that such a procedure had been proven to be poorly tolerated in other similar cases, because we believed the critical condition of the patient would not permit of a more lengthy operative procedure. The fact that the child lived is a tribute to the nurses and residents who attended it and to the carefully planned postoperative regimen of feeding outlined by Doctor Stokes.

The second patient was in better general condition at the time of operation. Our choice of procedure lay between duodenojejunostomy and gastrojejunostomy. The former procedure was not carried out because the extreme distention of the proximal duodenum had distorted the anatomy to a marked degree. It was feared that after decompression an angulation might occur at the site chosen for the anastomosis and thus give rise to a secondary obstruction.

TABLE I

Age at Operation	Recovered*	Died
30 hrs		yes
2 days		yes
4 days		yes
5 days	yes	
6 days	yes	
7 days	yes	
8 days	yes	
12 days	yes	
14 days	yes	
16 days		yes
23 days	yes	
29 days	yes	
3 mos		yes
4½ mos	yes	
5 yrs	yes	
8 yrs	yes	
9 yrs	yes	
12 yrs	yes	
Totals	13	5

* Two newborn babies with obstruction, probably from volvulus, recovered without operation.

In this case, eight months postoperatively, there is a persistent regurgitation of bile after feedings. The exact mechanism of this phenomenon has not been explained. It is possible that the continuance of the mechanism for the secretion of bile, after food has left the stomach rapidly via the jejunostomy, may bathe the gastric mucosa with undiluted bile for long periods. This condition may then give rise to irritation which in turn initiates and is relieved by regurgitation.

DR EDWARD J. DONOVAN (New York) said that at the Babies Hospital there have been 38 similar cases. For simplicity these may be divided into intrinsic and extrinsic lesions. The intrinsic lesions are usually a membranous diaphragm, a complete atresia and stenosis, which represents a lesser

degree of closure of the lumen. The extrinsic lesions are caused by (1) volvulus of the small intestine due to a failure of fixation of the ascending colon to the parietal peritoneum in the right lower quadrant of the abdomen, (2) developmental bands, and (3) fixation of the duodenum in an abnormal position. Both types of lesion are often associated with some error of rotation of the embryonic midgut loop. In the January issue of the American Journal of Diseases of Children, Doctors McIntosh and Donovan reported 20 cases, from the Babies Hospital, of malrotation of the intestine with duodenal obstruction. Of the intrinsic lesions of the duodenum there have been 18 cases, eight of whom died before operation could be performed. Ten of the 18 cases were operated upon and five died. All but two of the 20 cases with extrinsic lesions were operated upon and five of them died. The 20 cases with extrinsic duodenal lesions, therefore, did very much better. Table I shows the age at operation and the results of obstructions due to extrinsic lesions.

If the obstruction of the duodenum is complete, these patients suffer all the ills of high intestinal obstruction, and are often in bad condition when they are brought to the hospital. As soon as their fluid balance can be restored they are operated upon, and it often means subjecting a small baby to a very severe operative procedure which he cannot stand. The intrinsic lesions more often cause acute obstruction very early in life and for this reason the mortality is considerably higher.

The technical difficulties encountered in operating upon some of these cases, particularly where anastomoses have to be undertaken, and there is a great difference in the size of the two loops of intestine to be anastomosed, can be appreciated from Doctor Stetten's case report.

SURGICAL CONSIDERATION OF HYDATID DISEASE

REPORT OF SOME UNUSUAL CASES

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THE HIGH INCIDENCE of hydatid disease in Syria has been reported by Turner, Dennis and Kassir¹. In the Hospital of the American University of Beirut, the records of the surgical service show that during the last ten years (1928-1938) one out of every 150 patients had hydatid disease. Syria is a pastoral country. The interrelation between sheep and dogs, and the unhygienic way in which sheep are slaughtered, favor the maintenance of the life cycle of the *Echinococcus granulosus*, and while the water supply is being constantly improved there is still a great deal of pollution.

The distribution of the disease in the different parts of the body is similar, in Syria, to that in other countries. Our statistics show that it occurs in the liver in 50 per cent of the cases, in the lungs in 20 per cent, and in the other organs in 30 per cent.

The diagnosis is fairly easy in the majority of cases but may be difficult or impossible in others. A hydatid cyst may lie dormant in the body and give rise to no symptoms whatever, and it may be occasionally found during the search for other abdominal conditions or at autopsy. When the cyst grows in palpable organs such as the liver, spleen or kidney, it may be felt as a rounded, uniform, smooth and almost painless mass attached to the viscus or embedded in its substance, and is, as a rule, freely movable with the organ with which it is associated. If the cyst is rich in daughter cysts and near the body surface, it may give a fremitus (hydatid thrill) which may either be felt with the hand or, better, heard with the stethoscope. In cysts that are not accessible to palpation, such as pulmonary cysts, roentgenograms are an invaluable aid in diagnosis. They cast a well defined, rounded shadow which is uniform in density.

Hydatid disease was the first of the pathologic conditions caused by animal parasites in which serologic tests proved to be of great value in diagnosis. The complement fixation test of Weinberg, and the skin sensitivity test of Casoni, are very helpful in making a positive preoperative diagnosis. In our experience, the Casoni reaction was positive in 90 per cent of the cases demonstrated by operation to be hydatid disease. Occasionally a positive Casoni reaction will be obtained in a patient in whom hydatid infestation could not be found during operation. In these cases, there may be a small cyst which has not been found or the allergy may be the result of an infestation which was successfully taken care of by the tissue defenses of the body. The Casoni test is the method

of choice for testing a tentative diagnosis, but if it fails, a complement fixation should be done

The relation of hydatid disease to the body economy is significant, as, aside from infection and its untoward effects, the pressure of the cyst may prove incapacitating, harmful, dangerous and even fatal. One-fourth of our cases were infected before they came for operation, the colon bacillus being the most frequent invader. The mode of infection of the cyst with micro-organisms is not definite and the various theories advanced are not clear. The most plausible explanation is the occurrence of pericystitis extending from the capillaries of the adventitious capsule, where, owing to their tortuosity and the resulting stagnation of blood, a clot may be formed and become invaded by micro-organisms circulating in the blood stream. A suppurating hydatid cyst may be difficult to differentiate from an ordinary abscess.

The local effects of the cyst are manifest by a sense of discomfort and sometimes a disturbance of the function of the organ invaded. In hepatic cases, there may be severe jaundice from pressure on the bile ducts. They may rupture into the biliary ducts or into the intestines and discharge their contents into the bowel. Pulmonary cysts may produce a sense of oppression in the chest and very often cough and expectoration of blood-stained mucus, which is a misleading symptom often leading to a diagnosis of pulmonary carcinoma or tuberculosis. Cysts of the orbital cavity may interfere with vision. In the brain they may produce serious and distressing symptoms.

Rupture of a hydatid cyst into the peritoneal or pleural cavities may be very serious. Signs of severe anaphylactic shock appear very quickly. In the chronic cases the reaction seems to be milder. In two of our cases, there was a rupture of the cyst—one in the liver and the other in the spleen—into the abdominal cavity. Symptoms of mild anaphylactic shock appeared which were quickly relieved by adrenalin. One of these cases was seen two years later and evidenced no signs of any recurrence or abdominal involvement.

The surgical treatment of hydatid disease depends upon the location of the cyst and its situation in the organ. The old practice of tapping the cyst is to be condemned as both unreliable and dangerous. The ideal treatment is to excise the cyst with its adventitious capsule, but this is possible in only a few cases where the cyst is attached to the surface of the organ with a sort of pedicle and can be extirpated without damage to the organ.

Case 1—K. A., male, age 35, laborer, was admitted to the hospital, March 15, 1928. *Chief Complaint* An increasing bulging of the left eye of 15 months' duration. The left eyeball protruded almost out of the orbit. With the exception of a mild optic atrophy, the vision and the ocular tissues were unimpaired. A roentgenogram showed no bone lesion. Blood count 7,500 leukocytes, with 3 per cent eosinophils. Wassermann negative. A tentative diagnosis of nonmalignant tumor of the orbit was made.

Operation was performed under general ether anesthesia. A cyst the size of a small walnut was found between the eyeball and the orbit externally, surrounded by very loose adhesions. The cyst and its membranes were removed completely and the patient made an uneventful recovery. The cyst contained 15 cc. of straw-colored fluid and hooklets were seen under the microscope. When seen a year later vision had been completely recovered.

Case 2—G S, male, age 25, clerk, was admitted to the hospital, January 4, 1928
Chief Complaint Pain and heaviness in the right hypochondrium of four years' duration, associated with anemia and easy fatigability *Examination* showed a mass the size of a small grapefruit hanging from the lower border of the liver The mass was round, smooth and movable Hydatid thrill was elicited over the mass Casoni positive Blood showed 8,500 leukocytes, with 4 per cent eosinophils A diagnosis of hydatid of the liver was made

Operation was performed under general ether anesthesia On opening the abdomen the cyst was found loosely attached to the under surface of the liver It was very easy to enucleate and was entirely removed Recovery was uneventful and the patient was discharged, February 8, 1928 (Fig 1)



FIG 1—Case 2 Hydatid of the liver

In the majority of hepatic cysts, however, the cyst is found embedded in the substance of the liver but tends to bulge through to the periphery In these cases, the first concern of the surgeon is to determine the method of approach If the cyst is near the anterior border of the liver, on its under surface or in the left lobe, the best approach is through the abdomen The abdomen is opened by a vertical incision over the most prominent part of the cyst, and the capsule of the cyst is sutured by a continuous suture to the parietal peritoneum leaving an exposed area 4 cm in diameter In four to six days the two layers of the peritoneum become adherent, closing off the general peritoneal cavity (marsupialization) and the second stage of the operation could be undertaken

In the choice of the handling of the cyst we have been guided by the special indications present in each case We tap the cyst, inject 2 per cent formalin and after a few minutes open the cyst with the electric cautery The contents are then evacuated and with a sponge forceps the daughter cysts and cyst membranes are removed If the cyst cavity is large, we drain it If small, we fill it with normal saline solution and close it tight In a few cases, we have omitted the use of formalin without subsequent recurrence Cysts located in

the dome of the liver are treated like pulmonary cysts. Occasionally a cyst might be so large as to require a counteropening either through the abdomen or through the chest. If the two layers of the peritoneum or pleura are already adherent, the cyst is opened immediately.

All pulmonary cysts are handled in the following way. The cyst is carefully located by means of stereoscopic roentgenograms. The operation is performed in two stages. During the first stage, two or three ribs are resected over the area where the cyst is nearest the chest wall. In some cases the adventitious capsule of the cyst is seen moving with respiration within the pleura. In this case a circular suture is made fixing the capsule to the parietal pleura. When this is not possible a piece of gauze soaked in tincture of iodine is placed on the parietal pleura and gently pressed in. In ten to 14 days adhesions will have formed firm enough to allow the performance of the second stage. The cyst is then aspirated, opened with the electric cautery and its contents evacuated. In most cases we have been able to remove the cyst membranes in their entirety with a sponge forceps. In a few cases the membranes were very friable and it was impossible to remove them completely. The little that is left comes out on the dressings. None of the lung cysts were formalized, and we have had no recurrences. This method has given us satisfactory results though in some cases the recovery was slow. Multiple cysts of the lungs are not infrequent. In the treatment of such cases the cysts must be handled one at a time.

Case 3—F. D., female, age 25, housemaid, was admitted to the hospital, November 16, 1934. *Chief Complaint* Dull pain and heaviness in the left chest in the region of the scapula of eight months' duration. On May 2, 1934, the patient was seen at the Out-Patient Department, when a yellowish fluid was aspirated from the left pleural cavity (?) and a diagnosis of pulmonary tuberculosis made. *Examination* On admission there was dullness over the right apex and the left base. Leukocytes 7,750, with 6 per cent eosinophils. Casoni positive. *Roentgenograms* showed three opaque, rounded, intrapulmonary shadows clearly outlined. The first was the size of an orange, below the right clavicle, the second the size of a small grapefruit, above the left diaphragm, and the third a small one seen behind the second.

On November 29, 1934, the cyst on the left side was operated upon. Under local infiltration anesthesia, 5 cm. of the eighth and ninth ribs were resected along the posterior axillary line. The two layers of the pleura were seen to be adherent to each other (possibly as the result of the previous paracentesis). The cyst was tapped and the fluid contained hooklets and scolices. It was then opened with the electric cautery and the contents of the cyst as well as the cyst membranes were removed with a sponge forceps. A Pezzer catheter was inserted and the cavity drained. On January 3, 1935, the right cyst was operated upon under local anesthesia. Five centimeters of the fifth and sixth ribs were removed along the posterior axillary line. The pleura was sutured to the capsule of the cyst in a circular manner and the wound packed with sterile gauze. On January 15, the wound was exposed, the cyst tapped and the fluid found to contain hooklets and scolices. It was opened with the electric cautery, the membranes removed with a sponge forceps and a Pezzer catheter introduced into the cavity. On February 15, 1935, the roentgenologist reported "There are operative defects of the fifth and sixth ribs posteriorly on the right and the eighth rib laterally on the left. The rounded shadows in the left base have disappeared. The cyst of the right lobe is replaced by an annular haziness

surrounding an empty area (Figs 2 and 3) " On February 19, the patient was discharged completely recovered. Evidently the third small cyst must have emptied through the second.

Cysts of the spleen are not so rare, and are generally easy to diagnose. They may be treated as those of the liver, but if they are of large size, a splenectomy is the method of choice, especially as no adhesions are usually encountered.



FIG 2—Case 3 Hydatid of the lung (Before operation) FIG 3—Case 3 Hydatid of the lung (After operation)

Case 4—L. K., female, age 33, housewife, was admitted to the hospital, October 25, 1927. *Chief Complaint* A painless swelling in the left hypochondrium of two years' duration. *Examination* showed a mass the size of a large grapefruit, firm in consistency, rounded, painless, attached to the lower border of the spleen and freely movable. *Cason* positive. *Leukocytes* 8,300, with 5 per cent eosinophils. The diagnosis of a hydatid of

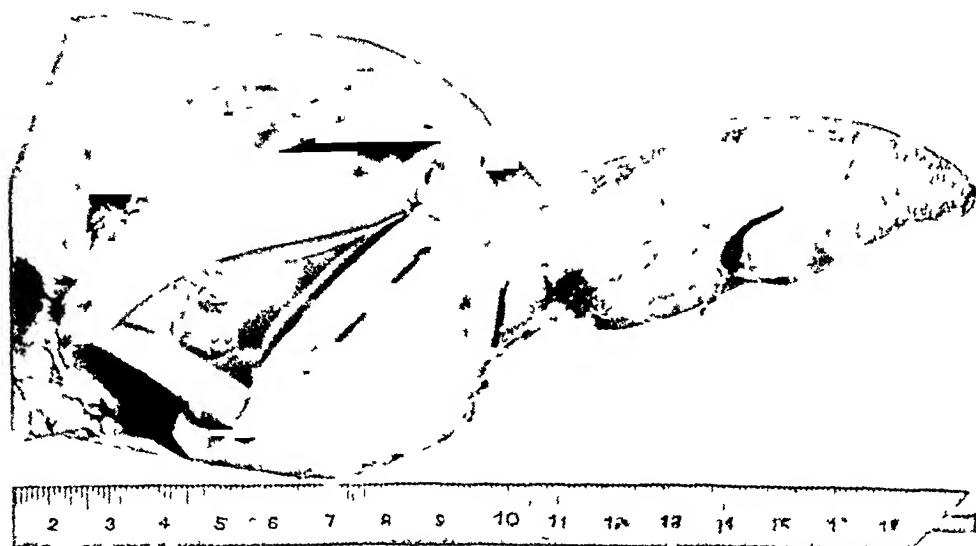


FIG 4—Case 4 Hydatid of the spleen

the spleen was made. Splenectomy was performed under general ether anesthesia, October 28. There were no adhesions, and the spleen and the cyst were freely movable. Recovery was uneventful and the patient was discharged, November 14. The cyst contained daughter cysts and hooklets (Fig 4). The patient was seen three years later and was in good physical condition.

Cysts of the kidney are more difficult to diagnose. Partial nephrectomy is the method of choice. If the cyst is large and the kidney tissue is damaged, complete nephrectomy is advisable providing the other kidney is in good condition.

Case 5—M Y, female, single, housewife, age 24, was admitted to the hospital, December 3, 1934. *Chief Complaint* A mass in the right upper quadrant of three years' duration. Retrograde pyelography showed an enlarged kidney with probable hydronephrosis. Leukocytes 6,750, with 3 per cent eosinophils. Blood urea nitrogen 7.5 mg. Renal function (P S P) 56 per cent—right kidney 16 per cent and left kidney 40 per cent. A diagnosis of tumor of the right kidney was made. On December 15, the patient was operated upon under general ether anesthesia. A cystic mass the size of a grapefruit was found protruding from the lower pole of the kidney. Clear fluid was aspirated, and immediate microscopic examination revealed the presence of hooklets and scolices. Nephrec-



FIG 5—Case 5 Hydatid of the kidney



FIG 6—Case 7 Hydatid of the brain

tomy was performed. Recovery was uneventful and the patient was discharged, December 26 (Fig 5).

Hydatid disease of the pancreas is rare. Masseron² has been able to collect the record of five cases only, and these were first recognized at autopsy. Graham,³ of Sidney, says "The hydatid is sometimes found in the pancreas. I have observed it as cyst about three inches in diameter replacing the head of the pancreas." Tricomi⁴ states, without giving any references, that seven cases have been recorded. One of the most interesting of our cases was a large hydatid of the tail of the pancreas.

Case 6—F M, female, age 40, housewife, was admitted to the hospital, September 19, 1926. *Chief Complaint* Pain and heaviness in the epigastrium with a feeling of fullness in the stomach after meals, of three years' duration. *Examination* revealed the presence of a deep-seated mass under the xiphoid cartilage, very slightly movable, rounded in contour and of firm consistency. It was the size of a grapefruit and situated behind the stomach. Under the fluoroscope the barium meal was seen to spread out in the stomach, taking the shape of a ring, caused by the pressure of the mass behind. Stool examination and stomach contents were negative. Wassermann negative. Leukocytes 7,500. No

HYDATID DISEASE

Cason or Weinberg was done as hydatid disease was not suspected *Diagnosis* Tumor of the pancreas

Operation—September 25, 1926 Under general ether anesthesia, a median, vertical subxiphoid incision reaching to the umbilicus was made On opening the abdomen, a mass the size of a grapefruit was found lying behind the stomach and lesser omentum The nature of the mass could not immediately be ascertained On opening the lesser sac a fluctuating cyst was seen arising from the tail of the pancreas The enlarged splenic artery was adherent to the capsule of the cyst The octahedral pavement effect produced by the daughter cysts revealed the nature of the condition The abdominal cavity was well protected with wet pads and the cyst aspirated Immediate microscopic examination showed the hooklets and scolices The fluid was aspirated, the cyst opened with the elec-



FIG 7—Case 8 Hydatid of the medulla

tric cautery and the contents evacuated The capsule was resected except the small portion that was attached to the splenic artery This small remaining portion was cauterized with carbolic and alcohol and doubly inverted by a continuous suture of chromic gut The lesser omentum was sutured and the abdomen closed The patient made an uneventful recovery and was discharged, September 30, 1926 This patient was seen in August, 1937 She was in good health with no signs of recurrence

Primary hydatid cyst of the brain is rare and the condition is generally incompatible with long life In our series we had two cases of brain cysts, both of which were recognized at the autopsy

Case 7—B S, female, age 25, was admitted to the hospital, February 25, 1932
Chief Complaint Impairment of vision since December, 1930, leading to complete loss of

vision in the right eye eight months later. Attacks of frontal headache with occasional vomiting. Ophthalmoscopic examination showed right optic atrophy. Leukocytes 4,750, with 2 per cent eosinophils. Wassermann of cerebrospinal fluid and of blood negative. Patient died, March 6, 1932. Autopsy showed a hydatid cyst of the right occipital lobe (Fig 6).

Case 8—A K, male, age 27, was admitted to the hospital, November 15, 1922. *Chief Complaint* Pain in the head and vomiting. Bilateral papillitis. Wassermann positive. *Diagnosis* Tumor of the brain, probably syphilitic. Patient died, December 9, 1922. Autopsy showed a hydatid cyst of the medulla encroaching upon the quadrate lobe of the cerebellum (Fig 7).

While hydatid cysts are often found in the liver and the lungs, they may be found anywhere in the body. We had three rather unusual cases as far as the site is concerned. One was a hydatid of the muscles of the back and the other two were in the buttocks.

Case 9—H M, male, age 59, peddler, was admitted to the hospital, April 12, 1933. *Chief Complaint* A painless swelling in the right loin of two years' duration. *Examination* A uniform, fluctuating mass the size of a grapefruit was found situated over the crest of the ilium. No limitation of motion of the vertebral column. Roentgenograms of the spine negative. No temperature. Leukocytes 6,300, with 8 per cent eosinophils. Casoni and Weinberg positive. *Diagnosis* Hydatid cyst (possibility of a cold abscess).

Operation—Under local infiltration anesthesia, April 15, 1933, a cyst was found arising from the muscles of the back. The aspirated fluid showed hooklets and scolices. The cyst was opened and evacuated and the membranes removed. The cavity was swabbed with tincture of iodine and closed without drainage. Recovery was uneventful and the patient was discharged, April 23. He was seen two years later and showed no evidence of recurrence.

The treatment of infected hydatid cyst is that of an ordinary abscess, namely, free incision at the most suitable site and the establishment of free drainage.

General ether anesthesia has been our anesthetic of choice, as it minimizes the occurrence of anaphylactic shock. In lung cases we have employed local infiltration anesthesia with $\frac{1}{2}$ per cent novocain with adrenalin, in order to prevent congestion of the lungs and coughing which might rupture the cyst and disseminate its contents into the bronchi and lungs.

SUMMARY

- (1) Hydatid disease is not rare in Syria. It forms 0.6 per cent of our surgical cases.
- (2) With our present diagnostic aids, diagnosis, in the majority of cases, is not difficult.
- (3) Cysts are usually located in the liver or lungs but may be found anywhere in the body.
- (4) A few rather unusual cases are detailed and their treatment described.

REFERENCES

- ¹ Turner, Dennis and Kassis. Trans. R. S. T. M. and H., 30, 2, 225.
- ² Masseron. These de Paris.
- ³ Keen's Surgery, 3, 1055.
- ⁴ Tricomi. Gaz. deg. Osped., 894, 1892.

LYMPHANGIOMATA OF THE GREAT OMENTUM

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LYMPHANGIOMATA, seen with some degree of frequency in other portions of the body, occur much less often in the abdomen and particularly in children. According to Ewing,¹ the solid tumors of the mesentery and omentum springing from the tissue within the peritoneal leaves are usually of connective tissue origin, as lipoma, fibroma, and sarcoma. These growths also present in the retroperitoneal space. Lipoma is the most frequent of the mesoblastic tumors in the peritoneal structures, but all are rare. Cystic growths of a more complex type are found in this region and are much more common here than the solid tumors. This appears to be particularly true also of the lymphangiomas, and they are almost all cystic in type. The solid or noncystic lymph vascular tumors are perhaps the rarest of all. Naturally, from the formation of the lymphatic vessels and particularly those in this region, cyst formation would be expected to occur. They sometimes reach large size because of the vascularity of the region and the looseness of the structures. It is noteworthy that tumors of loose cellular structure grow more steadily under these conditions, even though essentially benign in character. These cysts are thin-walled and have a limited blood supply. They are usually filled with a pale serum but sometimes contain a dark or even bloody fluid. In a few cases such growths, closely adherent to the intestinal tract or in intimate relation to the lymph ducts, may contain a milky fluid—chyle cysts. Rarely the neoplasm, as in our case, is made up for the most part of firm lymphatic and connective tissue with little or no fluid content. They usually cause symptoms by pressure upon surrounding structures creating distress and discomfort rather than actual pain. The exceptional cases cause pain because of the involvement of some portion of the gastro-intestinal tract, with obstruction of its lumen or constriction of its vascular supply. These growths are essentially benign and usually do not recur after removal.

From the frequent blocking of the lymph channels in the great omentum, due to pelvic and other inflammatory disease within the abdomen and with considerable trauma to the omentum, tumors would be likely to result more frequently if they were caused by such occurrences. Apparently this result does not follow, and one is justified in concluding that most omental growths are congenital in origin, as has been suggested by Nasse,² Ribbert,³ Sisk⁴ and others, notwithstanding Wegner's original experiments on the injection of air and filling the abdominal cavity under pressure and choking the lymph channels, resulting in the production of large cysts with proliferative changes in the

walls Undoubtedly blocking of the channels either from inflammatory or neoplastic change increases the growth of the tumor Omental growths usually show serous or blood-tinged (sometimes quite dark) fluid within the cysts and differ materially from the milky fluid found in chylous cysts resulting from obstructions of the lymph ducts draining the lacteals In rare instances omental lymphangiomas may show but very small cysts and their structure consist largely of true lymphangiomatous tissue with considerable, rather loose, connective stroma

Sabin,⁵ Huntington and McClure (mentioned by Singleton⁶) have thrown new light on the development of the lymphatics Huntington and McClure⁷ seem to have established the fact that the development of the lymph vessels begins at definite centers and from such a center vessels spread outward, vascularize and drain a definite area Excisions of the starting center result in no growth and vessels from neighboring areas invade and drain the one thus deprived These findings seem to agree with the well-known tendency of lymphatic structures, both glandular and vascular, to increase in size, number, and activity and to overcome irritants, traumatic, chemical, bacterial or toxic These vessels and glands also have the power to return to their normal size and distribution when the causative agent is destroyed or removed The entire process of nutrition is so closely dependent upon lymphatic absorption and distribution of fluids that wonder is not excited by the great activity of these structures in defense of the organism against disease and in repair of damage of all kinds

The study of 53 cases of lymphangiomas of the omentum by A H Montgomery and I J Wolman,⁸ in 1935, is most comprehensive, 35 of these cases were under 11 and 18 over 11 years of age It appears, therefore, to be an affection of childhood, and this fact taken in connection with other circumstances points to its congenital origin In the 53 cases recorded, only in one case was the correct preoperative diagnosis recorded In part this is due to the slow onset and the vague history but it also is the result of the rare occurrence of the affection as well as the difference in the physical findings

The important point is to keep in mind the fact that such a neoplasm does occur in childhood Some cases begin as a small, mobile, painless growth in the abdomen of an infant The condition is more likely to present in the epigastrium, the umbilical or right lower quadrant It will usually be smooth and irregularly round until it becomes attached to the abdominal wall, the intestine or some other structure from inflammatory adhesion Fluctuation is likely to be elicited early in its development Pain is not important early in most cases The first symptoms, however, may be the result of a torsion of the omentum or intestinal stasis from obstruction of the lumen or from blocking of the intestinal blood supply Under such conditions the case becomes a grave surgical emergency

Even in the early stages in younger children malnutrition is evident, with constipation from the effect of pressure, while occasionally a troublesome diar-

rhea persists Nausea and vomiting are often present at the onset Such occurrence is so frequent in infants that its cause may be searched for in some more usual lesion and a neoplasm overlooked The fact that it does occur in infancy should be kept in mind by the observer In the early stages of its development any of the acute ills of an infant are to be differentiated In the later stages its recognition is based upon its slow development, its increasing size, the contour of the abdomen without any evident increase in general nutrition An afebrile condition also points in its direction although fever, leukocytosis and general distress with abdominal rigidity may simulate appendicitis

Tuberculous peritonitis is most likely to be mistaken for lymphangioma, but tuberculous lesions are more likely to be irregular in contour Both conditions are likely to be accompanied by ascites and then a fluid wave is elicited, together with a flat percussion note Sarcoma grows with more rapidity and affects the health of the patient more promptly It is also more rapidly fatal⁹

In older patients, ovarian cysts, renal and splenic growths, torsion of the omentum or of an ovarian cyst may confuse the clinician Prolonged observation can only confuse, and if the use of radiologic investigation with intra-peritoneal air added, if necessary, does not clarify the diagnosis, an open abdomen will disclose the trouble and perhaps afford relief

The report herewith submitted adds another lymphangioma of the omentum to the 53 cases previously reported in surgical literature In this instance a diagnosis of intra-abdominal tumor with pressure symptoms was charted before operation

Case Report—P P, female, age three, was admitted to the hospital, January 20, 1937 About three months previously the mother noted an enlargement of the child's abdomen which has been progressive during the past week, dyspnea has been extreme, accompanied by pain in the abdomen Intermittent vomiting has occurred The past history is essentially negative, with the absence of childhood diseases

Physical Examination—One was immediately impressed with the extreme condition of the child, which presented an anxious face with flushed cheeks, some cyanosis, and marked dyspnea

The abdomen is very much distended, enlarged and rounded in contour due to an intra-abdominal mass The skin has a waxy appearance There is generalized tympany, and on palpation a doughy resistance is felt This large tumor is movable slightly in all directions and on manipulation causes the child to cry out Some few superficial veins of the abdomen are dilated The umbilicus is flat and continuous with the skin level On percussion no fluid wave is transmitted

Laboratory Data *Urine*—Straw, turbid, acid, specific gravity 1.021, albumen, heavy trace, sugar negative, acetone negative, casts hyaline 2 LPF coarse granular, 3 LPF fine granular, 5 LPF epithelium, few renal, pus cells occasional, mucus shreds occasional An examination of the blood showed hemoglobin 11 Gm, 65 per cent, color index 0.8, erythrocytes 4,300,000, leukocytes 4,350, S lymph 24 per cent, L mononuclears 8 per cent, polynuclears 64 per cent, eosinophils 4 per cent, juv 4 per cent, stab 2 per cent, seg 58 per cent **Preoperative Diagnosis** Large intra-abdominal tumor with extreme pressure symptoms

Operation—January 26, 1937 Under ether anesthesia, a midline incision was made, which disclosed a large, slightly irregular mass which filled the entire abdomen It was at first thought to be attached to the left broad ligament, but on more careful examination

it was found to be a tumor of the great omentum with a very small pedicle and slight vascularity. The attachment was just to the left of the midportion of the transverse colon. The tumor was easily delivered and the pedicle ligated close to the colon. The abdomen was closed. There followed an uneventful recovery with dismissal from the hospital on the thirteenth postoperative day.

Pathologic Examination Gross—Cystic, fluctuant tumor measuring approximately 170 Mm in greatest diameter by about 120 Mm in width and thickness. The outer surface is smooth but slightly irregular in contour due chiefly to the distribution of blood vessels. The site of attachment is slightly roughened. The tumor, on being opened, is found to consist of a single chamber which has a smooth, glistening lining, containing a watery, slightly yellowish-tinged fluid.



FIG 1—Photograph of the gross specimen of the lymphangioma of great omentum which was removed

Microscopic—Sections of the wall of the cyst show a somewhat hyalinized fibrous tissue. This is relatively acellular. In places the spaces between the fibers are infiltrated by lymphocytes and eosinophils. There are also small oval and elongated narrow channels in the thicker portion of the wall of the large cyst. These small spaces contain an amorphous eosin-staining substance. They are lined by long flattened cells which appear to be endothelial cells. Much of the inner surface of the large cyst is void of lining endothelial cells. This, probably, is the result of atrophy due to the presence of fluid within the cyst. *Pathologic Diagnosis* Benign lymphangioma of the great omentum.

SUMMARY AND CONCLUSION

(1) A rare tumor of the great omentum, lymphangioma, is reported. A careful search of the surgical literature reveals 53 to have been previously described.

(2) A brief resume of lymphangiomata, especially of the great omentum, is presented.

(3) When confronted with an abdominal tumor in a child, one should not forget the possibility of lymphangioma of the great omentum.

BIBLIOGRAPHY

- ¹ Ewing Neoplastic Diseases, 228
- ² Nasse, D Arch f klin Chir , 38, 614, 1889
- ³ Ribbert Virch Arch , 141, 381, 1898
- ⁴ Sisk, C Virch Arch , 170, 9, 1902
Ibid , 172, 445, 1903
- ⁵ Sabin, Florence R Lymphatics, Lymph and Tissue Fluid Drinker and Field, Williams & Wilkins Co , 2, 1933
Idem The Origin and Development of the Lymphatic System Johns Hopkins Hosp Rep , Monographs, N S , 5, 94, 1913
- ⁶ Singleton, Albert O Trans Southern Surg Assn , 49, 329, 1936
- ⁷ Huntington and McClure The Anatomy and Development of Systemic Lymphatic System Memoirs of Wistar Institute of Anatomy and Biology, 2, 1911
- ⁸ Montgomery and Wolman Lymphangiomata of Great Omentum, 60, 695, 1935
- ⁹ Sherrill, J Garland Tuberculous Peritonitis, Monograph on Peritonitis D Appleton and Company, 221-224, 1925

LIVING FASCIAL SUTURE IN THE REPAIR OF LARGE INGUINAL HERNIAE *

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SINCE the introduction of living fascial suture in the repair of inguinal herniae by McArthur, in 1901, very few surgeons have adopted this method either as a routine or as an occasional procedure. We feel that the operation has not received the acclaim that it deserves, since in all published reports the results have shown a striking improvement over other and more popular operations.

That the McArthur operation can be performed in conformity with the fundamental principles of the radical operations of Bassini, Halsted or Andrews is equally true, using, however, living fascial suture derived from the aponeurosis of the external oblique muscle, instead of absorbable or inert suture material. It is axiomatic, however, that large and especially direct inguinal herniae demand an unusually high individualization so far as operative maneuvers are concerned. No one procedure is applicable to all herniae in this location, and many factors must influence the choice of operation. Nevertheless, an operation which will materially reduce the number of recurrences in the difficult cases should certainly be considered as possessing advantages in all cases, provided it does not increase the operative hazards and its performance is not beyond the technical ability of the average surgeon.

The use of fascia in operations for hernia was first reported by McArthur, in 1901, and there followed a second article, in 1904, in both of which he stressed the superiority of fascia over the ordinary suture materials. He made use of strips of fascia derived from the aponeurosis of the external oblique muscle and repaired the hernia according to the method of Bassini. He stated that other methods of suturing are dependent upon the development of cicatricial tissue between the sutured surfaces and that failure will inevitably develop in a number of cases because the cicatrix will yield to pressure. He demonstrated by microscopic sections that his autoplasmic suture healed *in situ*, that it was not absorbed and did not slough.

Attempts to close a large defect in the floor of the inguinal canal, by ordinary methods, are not always successful. The use of catgut, kangaroo tendon, silk or linen affects adhesions, if successful, and many times the sutures must be applied under tension. It has been our experience that when ordinary

* Read before the Philadelphia Academy of Surgery, January, 1939. Submitted for publication March 24, 1939.

sutures are applied under tension, they frequently cut through the sutured structures. Or, when they are absorbed, the weakness or defect recurs.

This is not true of fascia sutures. Gallie has shown that there is no inflammatory reaction excited, the fascia survives for years, if not indefinitely, it unites with the tissue in which it is embedded, has great tensile strength, and does not stretch under pressure as does scar tissue. The importance of this difference cannot be too greatly emphasized, because the support from the classic type of repair is as strong as the scar which unites the structures forming the floor and roof of the inguinal canal. The tendency of scar tissue to stretch and give way under pressure is, in most instances, the responsible factor in recurrences.

It may be stated as a truism that there are definite anatomic differences between the direct and the indirect hernia. These differences are much more fundamental than whether the hernia lies lateral or medial to the deep epigastric vessels. Robins has emphasized the deficiency of the structures at the pubic end of the canal in direct hernia, demonstrating the absence of a conjoined tendon, by the direct passage across the floor of the inguinal canal, of the internal oblique and transversalis muscles, leaving a defect at the lower end of the canal. In addition, the fibers of the lower border of these muscles have been shown to be weak and attenuated. The greatest defect is at the border of the rectus and from there it extends lateralward with a diminishing width, often as far as the abdominal ring. Because of this, the floor of the canal is often weak throughout its extent. The importance of repairing this defect cannot be too greatly emphasized.

The presence of a preformed sac in the indirect hernia has led certain surgeons, notably those of Great Britain, to practice high ligation of the sac and nothing further in the surgical cure of these cases. That this is sufficient many times, is attested by the large number of cured cases reported. However, its use has been restricted largely to children, and with this practice the writers are in accord. In the large indirect herniae, and particularly those which have existed for many years, the anatomic defect present closely resembles that which exists in direct hernia, namely, weakness and attenuation of the fibers of the internal oblique and transversalis muscles and a poorly developed conjoined tendon. Consequently, we feel that in all these cases, as well as in all direct herniae, fascial sutures should be employed in order to secure a larger number of permanent cures.

The incidence of recurrence following the radical operation for inguinal hernia varies somewhat, and there are many factors which must be considered in evaluating these statistics. Table I shows the percentage of recurrence from several representative clinics.

Table II shows the statistics which have been reported by several surgeons employing the McArthur technic or modifications of it. A study of these two tables will show a surprising superiority in the results obtained by the use of fascia suture over those using any other type of suture material, regardless of the operative procedure employed.

TABLE I
INCIDENCE OF RECURRENCE

Author	No of Cases	Dir		Recurrences		Percentage of Recurrences
		Dir	Ind	Dir	Ind	
West-Gibson-Cupp	828					7 24%
Page (London policemen)				25 0%	20 0%	
Cumberlidge	517					8 7%
Andrews-Bissel	1,400			28 0%	20 0%	
Lyle	275	75	200	13 0%	9 0%	10 1%
Coley	837		837		18 0%	18 0%
Erdman (over 60)	978			42 0%	10 0%	
Fallis	800	154	646	11 6%	7 4%	
Hoguet	1,212	249	963	6 8%	1 6%	
Lameris	613	102	511	28 4%	3 9%	
Druener	673	171	502	18 0%	5 0%	
Taylor		256	2,230	18 0%	5 6%	

We wish to report at this time our results in the performance of this operation, to discuss the technic of this procedure, and to report and analyze our failures. Unfortunately, we cannot report 100 per cent of cures, but we feel that we have significantly reduced the number of recurrences in dealing surgically with these difficult cases.

TABLE II
INCIDENCE OF RECURRENCE FOLLOWING THE MCARTHUR METHOD

Arthur	No of Cases	Dir		Recurrences	
		Cases	Ind	Dir	Ind
Robins	27		27	0 0%	
Cambassis	25			0 0%	0 0%
Keynes	100	45	55	0 0%	0 0%
Lyle	154	54	100	9 0%	3 0%
Cattell-Anderson	174	51	123	7 8%	4 6%

Table III shows the results obtained in our operations upon 82 cases. Most of these cases have been examined postoperatively by one or the other of us, or by the family doctor. A few have reported by mail. As will be

TABLE III
ANALYSIS OF 82 HERNIAE REPAIRED BY FASCIAL SUTURE

<i>Authors' Series</i>	
Total cases	82
Direct hernia	45
Indirect hernia	37
Bilateral hernia	8
Recurrent hernia	2
Recurrences	3
Direct	2
Indirect	1
Percentage of recurrences	3 6%

noted, we have had three recurrences. Let us first consider these recurrences individually.

ABBREVIATED CASE REPORTS OF THREE INSTANCES OF RECURRENCE

Case 1—C. E., white, male, age 55, was admitted to the Chestnut Hill Hospital, May 24, 1931, for the repair of a right indirect inguinal hernia. The patient stated that the hernia had been present for many years and had considerably increased in size. Examination revealed a large indirect inguinal hernia, which was easily reducible. The internal ring was considerably dilated.

Operation—May 24, 1931. A Bassini herniorrhaphy was performed, using the McArthur technic. Convalescence was uneventful and the patient was discharged, June 13, 1931.

Several weeks after returning home the patient's wife developed a cerebral apoplexy and the patient stated that it was necessary for him to carry her about. Shortly thereafter the hernia recurred. The undue effort indulged in by this patient so soon after operation undoubtedly was a contributing factor to the recurrence. At present time the patient is wearing a truss, which is unsatisfactory.

Case 2—T. P., white, male, age 55, was admitted to Chestnut Hill Hospital, July 7, 1937. The patient stated that he noticed a "lump" in the left inguinal region about one year ago. Examination revealed a direct inguinal hernia.

Operation—July 8, 1937. A Bassini herniorrhaphy was performed according to the method of McArthur. Convalescence was uneventful and the patient was discharged, July 30, 1937. He returned to work at the end of six weeks. Six months later the patient had a small recurrence at the upper end of the inguinal canal, in the region of the internal ring. This patient has subsequently been operated upon at another hospital.

This case emphasized the importance of securely closing the internal ring. Recently, we have adopted the method of suturing the external oblique beneath the cord, in order to afford greater stability to the floor of the inguinal canal and to reinforce the internal ring.

Case 3—G. B., white, male, age 55, was admitted to Woman's College Hospital, May 17, 1936. He stated that he had had a rupture on both sides for several years. Examination revealed a bilateral direct inguinal hernia. Examination of chest revealed a chronic bronchitis.

Operation—A bilateral inguinal herniorrhaphy was performed, according to the method of McArthur. There was a large defect present in the floor of the inguinal canal, on both sides, and considerable tension was placed on the suture line.

Postoperatively, the patient had an exacerbation of the bronchitis with persistent cough. He was discharged from the hospital in good condition, June 9, 1936.

One year later there was a recurrence on the right side, which we have recently repaired with a strip of fascia lata.

In retrospect, it is quite likely that it would have been safer to have repaired one side, then, after an interval of three months, to have repaired the other side. This would have lessened somewhat the tension on the suture line. Also, the exacerbation of the bronchitis and the persistent coughing undoubtedly were a factor in the recurrence in this instance.

Operative Technic—The technic which we follow has been changed from time to time as increasing experience has taught us certain important details.

The inguinal area is exposed through a long, oblique incision from the

anterior superior iliac spine down to the spine of the pubis. The aponeurosis of the external oblique muscle is divided, from below, upward, from a point just medial to the center of the external inguinal ring, to the point where the aponeurosis and the muscle blend. The hernial sac is handled in the classic manner, of high ligation. We prefer to transplant the neck of the sac beneath the internal oblique muscle.

A strip of fascia, about one-quarter of an inch in width, is then separated from the medial leaf of the external oblique aponeurosis. It is left attached at its lowermost point to the spine of the pubis. Its upper end is detached from the muscle fibers. The upper end is then threaded into the special "Vollrath atraumatic link for connecting fascial suture to the Gallie needle" (Fig 1).

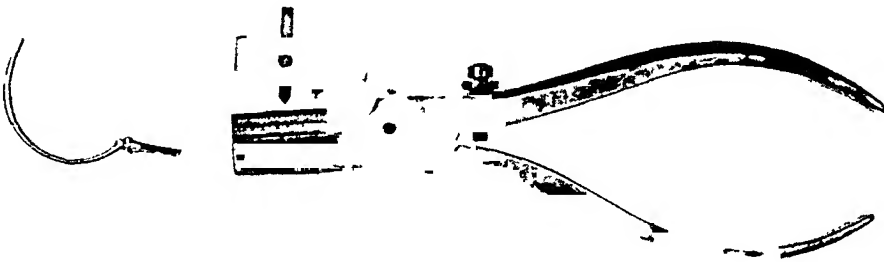


FIG 1—Vollrath atraumatic link for connecting fascial suture to the Gallie needle. The needle with attached link is shown, with the punch used for attaching the fascia.

The first stitch is important, because it should obliterate the weakness at the lower end of the floor of the inguinal canal. The needle, with the attached fascia, is first passed through the conjoined tendon and then through the reflected portion of Poupart's ligament, known as the triangular ligament. This closes the lower end of the canal. The suture is then passed back and forth, uniting the conjoined tendon and the internal oblique and transversalis fascia, to the shelving edge of Poupart's ligament (Fig 2). A goodly amount of tissue is included in each suture, which gives the effect of transplanting the structures rather than simply a suture line. We believe it advisable to fix each loop of fascia with a fine linen or silk suture to anchor it in place more securely. When the internal ring is closed snugly, the suture is fastened at its upper end either by splitting it and tying it in a double knot, or simply by suturing it with two encircling and transfixion sutures of silk or linen. It was formerly our practice to suture the external oblique aponeurosis over the cord. Recently, we have been suturing the aponeurosis beneath the cord, as we feel that this gives more stability to the repair. Catgut, silk or linen may be used for this purpose. We do not follow the original plan of McArthur who used a second strip of fascia to suture the aponeurosis. This we believe to be unnecessary. Occasionally, there may be some difficulty uniting the edges of the aponeurosis, in that case the cut edges may be sutured to the internal oblique muscle.

This technic is applicable in practically every inguinal hernia. Occasionally, in recurrent herniae, the aponeurosis may be so shortened and adherent that it is unsuitable for use as a suture. In those cases the operations described by Gallie, Wangenstein and others are indicated.

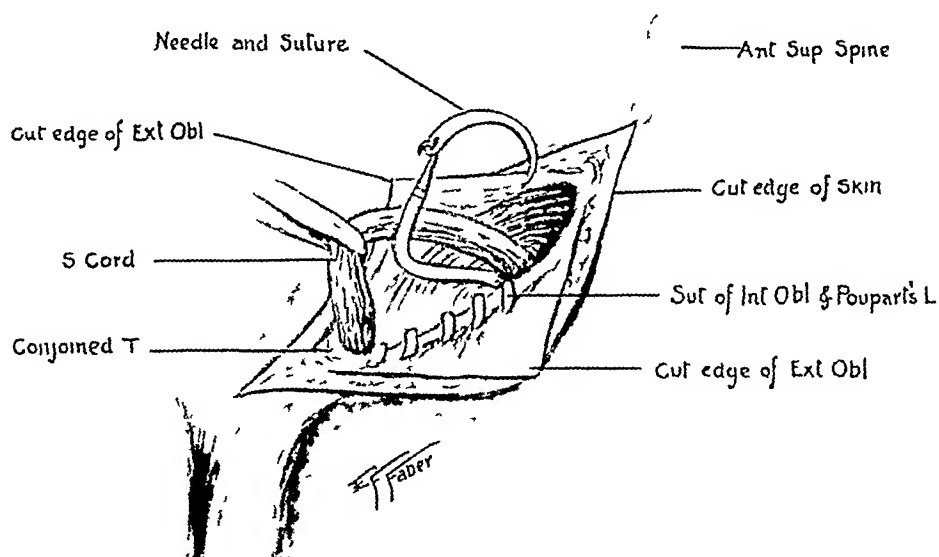


FIG 2—Showing the fascia suture in place, after the suture of the conjoined tendon and internal oblique to the shelving edge of Poupart's ligament

SUMMARY

- (1) Living fascia, in the repair of large herniae, is superior to all other forms of suture material
- (2) The importance of closing the defect in the floor of the inguinal canal is discussed
- (3) A comparison of the results of the McArthur technic, with other operations, clearly shows the superiority of the former method
- (4) Our results, in the performance of this operation in 82 cases, are presented
- (5) The technic which we follow is presented in some detail

Discussion—DR S DANA WEEDE (Philadelphia, Pa.) The problem of recurrence in the surgery of inguinal hernia falls under two headings—wound healing and dynamics

Undoubtedly, the most important consideration in wound healing is infection. All those conditions, therefore, that favor infection should be avoided, such as leaving dead spaces, rough handling of tissues, blunt dissection, use of large and irritating sutures, buying of dead organic material, and the cutting off of blood supply by improper suturing. Under wound healing, there is ample reason to believe fascia to fascia secures a stronger union than muscle to fascia.

In considering dynamics, it will be observed nature provided an obliquity to the inguinal canal. This undoubtedly provides a stronger arrangement than if the internal abdominal ring and the external abdominal ring were in a

direct line with each other through the abdominal wall and there existed no obliquity to the canal

In both types of operations, upon which the modern repair of inguinal hernia depends—the Bassini and the Ferguson—the new external ring is found superimposed over the site of the internal ring and the obliquity of the canal is lost. In the Bassini, the new site of the external ring is at the position of the internal ring, and in the Ferguson, the new site of the internal ring is at the position of the external ring. The site of recurrence after a Bassini is at the internal ring, and in the Ferguson at the external ring.

Two measures have been adopted, therefore, to strengthen these particularly weak areas. The fascia endo-abdominalis or transversalis fascia is used to repair the internal ring in indirect herniae, and in direct herniae it is used to strengthen the floor of the canal in the region of Hesselbach's triangle.

Finally, to restore the obliquity of the canal, I have sutured the aponeurosis of the external oblique, the internal oblique and transversalis muscles to the shelving edge of Poupart's ligament, *over* the cord, to a point midway between the internal ring and spine of the pubes. From that point down to the spine of the pubes those structures are sutured *beneath* the cord. The lower portion of the incised aponeurosis of the external oblique is now sutured over the cord to the point where the cord emerges, it is cut, fitted around the cord and sutured under the cord from there down. In this way, both weak areas, the site of the internal ring and of the external ring, secure the maximum strengthening and the obliquity of the canal maintained.

DR L. K. FERGUSON (Philadelphia, Pa.) I have been employing wire sutures in herniae for about four years. In a series of about 142 cases, which I recently had an opportunity to review, there occurred five recurrences. My experience with the use of wire has led me to employ it almost to the exclusion of other suture materials, and I have not resorted to the use of fascia because wire sutures have proved so satisfactory. The reaction in the tissues with wire is less than obtained with catgut and even less than with silk. In all of these cases, with few exceptions, a local anesthesia has been used.

I have grown so confident in the strength and durability of wire sutures that I frequently allow the patient to be out of bed on the day after operation, if it is necessary for him to be erect to void without catheterization. As a rule, the patients are permitted out of bed on the third or fourth day after operation in cases of small indirect inguinal herniae. I believe that it is particularly important for patients to be allowed out of bed early if they are elderly. This measure has appealed to me as one of the most satisfactory for use in preventing postoperative pulmonary complications and phlebitis.

I find that, as Doctors Lehman and McCloskey have noted, recurrences occur almost invariably within the first year, and, as a matter of fact, in almost all cases within the first six months, or even within the first three months after operation.

DR HENRY P. BROWN, JR (Philadelphia, Pa.) There is one suggestion which I believe helps considerably in the prevention of recurrence of hernia, namely, to thoroughly remove the areolar tissue which covers the inner surface of the inguinal ligament before suturing the transversalis fascia, internal and external oblique muscles and conjoined tendon to the ligament.

This layer of areolar tissue may be regarded as having a function somewhat analogous to that of the oil in an automobile cylinder, in that when the oil is present the piston glides freely within the cylinder and when absent the piston sticks tightly to the cylinder. In a like manner, when this areolar tissue

is allowed to intervene between muscle and ligament, firm union is much less apt to occur than when the muscles and fascia are brought into direct contact without the interposition of this areolar tissue

I also find it advisable to place one or two sutures uniting muscle to ligament to the outer side of the cord. These are steps of precaution which I believe justify their use

DR J A LEHMAN (closing) The average age of the patients was about 40. It has been our experience also that most recurrences occur a short time after operation, the three recurrences in this group occurred within one year. The patients in this series were all operated upon prior to 1938. I have no statistics on infection. We did have some, but I am sure the percentage was not very high.

DR J F McCLOSKEY (closing) I believe that fascial suture has a definite place in surgery as an adjunct in the treatment of hernia. An important factor in the cure of hernia is the position of the patient after operation. I use the semi-Fowler position, with the thigh flexed and the knees drawn toward the opposite shoulders. I believe when dealing with large herniae and in old men the best results are obtained by performing castration. One can generally, obtain a cure even in the large herniae.

USE OF WHOLE BLOOD AS A MEANS OF PREVENTING PERITONITIS AND ADHESIONS

A PRELIMINARY REPORT

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FROM THE MEDICAL SERVICE OF THE HADASSAH HOSPITAL JERUSALEM PALESTINE

IN THE YEAR 1936, Jerusalem the "City of Peace" became the "City of Turmoil," for its hospitals were filled with patients suffering with all manner of gunshot wounds

Emergency celiotomies were performed by day and by night, water in the sterilizers was kept constantly boiling, and numerous outfits for intravenous therapy were always in readiness. Many patients died, on the other hand it was remarkable how many patients recovered, even though their bowels were torn open in several places and even though fecal matter was found floating freely in the peritoneal cavity.

In particular, there was one patient who was very severely wounded in the abdomen and was brought in in a state of extreme shock. The descending colon had been torn across and the ileum was ruptured in two places, moreover the peritoneal cavity was filled with blood, and distributed about in the area of the torn colon was some considerable amount of feces. The injured viscera were repaired, the bleeding vessels ligated and the abdomen was closed without drainage. This patient made an uneventful recovery. This and other cases of a similar nature made a deep impression upon me.

It was difficult to understand how it was that these patients, flying, as it were, in the face of a potential peritonitis, had yet escaped without a severe fulminating infection and its logical sequence. What was the difference between these emergency operations, conducted under such unfavourable conditions, and the usual carefully conducted resection of the large bowel, which, in spite of the utmost precaution, so often ends with a fatal peritonitis?

It is obvious that, whereas, the systematic resection of the bowel is conducted in a perfectly dry field, these emergency operations were undertaken in a field swimming with blood.

There seemed no other essential difference between these two procedures, and it was felt that, possibly, the presence of the blood had had a beneficial effect and might have prevented the occurrence of peritonitis.

Accordingly, experimentations upon animals were carried out in an endeavour to substantiate the theory that fresh blood is capable of augmenting the natural defence mechanism of the peritoneum.

Before giving the results of these experiments it would be of interest to refer briefly to the bibliography of peritoneal immunity.

Previous Investigations of Peritoneal Immunity—Issayeff,¹ in 1894, found that the intraperitoneal injection of sterile irritants such as blood serum, broth, and NaCl solution increased the peritoneal resistance to bacteria. He found that these irritants were only moderately effective and at the same time there were local systemic reactions usually unpleasant and often severe.

Steinberg^{2, 3} showed that satisfactory peritoneal protection is determined by three factors:

(1) A sufficiently large number of phagocyte cells must be mobilized to phagocytose invading bacteria and to prevent bacterial multiplication and elaboration of subtle toxic substances.

(2) Such a mobilization requires retention of the leukocyte-evoking antigen within the peritoneal cavity. Most antigens including ordinary suspension of bacteria leave the peritoneum too rapidly to be effective.

(3) Steinberg showed that a solution of gum tragacanth holding in suspension a prepared strain of *Escherichia coli*, treated by long exposure to a weak solution of formaldehyde, fulfilled these requirements.

Sparks⁴ injected blood together with a broth suspension of bacteria into the peritoneal cavity of dogs. He found that autogenous blood together with varying types of pathogenic organisms injected into the peritoneal cavity of dogs did not predispose to the production of peritonitis.

Rankin, who previously had recommended intraperitoneal vaccination as a means of protection against peritonitis, has, in recent papers, definitely advised against this practice.

Experiments upon Animals—In order to investigate the theory that free blood in the peritoneal cavity increases the resistance of the peritoneum against infection, it was necessary to produce peritonitis in animals. The experiments were divided into three categories:

Group I The abdomen was opened and some feces were inserted into the peritoneal cavity and the wound was closed. This procedure was carried out on 10 rabbits and two dogs. Of these animals, only one died.

Group II The abdominal cavity was opened and feces were inserted, in addition, the sigmoid colon was incised transversely and immediately closed by two rows of catgut sutures. This procedure was carried out upon five rabbits and seven dogs. Of these animals, all developed peritonitis but one, and this dog developed a paralytic ileus.

Group III The same procedure as in Group II was carried out but in addition fresh blood was inserted into the peritoneal cavity. In the case of dogs, 50 cc. of blood were inserted into the peritoneal cavity.

Method of Blood Injection—The abdomen was sutured in the usual way but a catheter was left at the angle of the wound. At this point a suture was inserted but not tied. Blood taken from the animal was mixed with citrate solution and then injected through the tube. The catheter was then withdrawn and the suture tied. Eight dogs were treated in this way. Of these animals, six survived. The two dogs who had died were examined and it was found that their deaths were caused, not by peritonitis but from a severe

infective necrosis of the abdominal wall, there were no adhesions in the peritoneal cavity of these two animals

Several dogs of this group who did not die were afterwards sacrificed and the peritoneal cavities were found to be absolutely free from all signs of adhesions

TABLE I

	Number of Animals	Number That Developed Peritonitis	Percentage
<i>Group I</i>			
Abdomen opened and feces inserted	Rabbits 10	1	10%
	Dogs 2	0	0%
<i>Group II</i>			
Abdomen opened, feces inserted and sigmoid incised	Rabbits 5	5	100%
	Dogs 7	6	85%
<i>Group III</i>			
Abdomen opened, feces inserted, sigmoid incised, and fresh blood injected	Dogs 8	2	25%

It was found impossible to conduct these experiments upon pregnant animals since the resistance of the peritoneal cavity was so greatly reduced by the pregnancy

COMMENT—The extraordinary difference in the percentage mortality between Group I and Group II definitely proves that contamination of the peritoneal cavity with feces is not in itself sufficient to produce a fatal outcome. A superimposed injury or lowering of the vitality of the peritoneum must also be added.

Whether the evisceration of the bowel produces this injury or whether the opening of the colon itself provides this trauma is not at all clear. Possibly both factors acting together contribute to lower the peritoneal vitality and cause it to succumb to the bacterial infection.

The difference in the results between Group II and Group III would serve to indicate that free blood in the peritoneal cavity increases the resistance of the peritoneum by 75 per cent.

Two of the dogs in Group III who had died showed at autopsy that their deaths had not been caused by peritonitis inasmuch as they had died as a result of a severe infection of the abdominal walls with necrosis of the muscles and surrounding tissues. This infection was possibly the outcome of contamination acquired during the introduction of feces.

There seems to be a definite relationship between the presence of blood in the peritoneal cavity and the production of adhesions.

In Group II, in which feces were inserted without the addition of blood, the majority of the animals were shown at autopsy to have suffered with an intense peritonitis, with severe matting and adhesions of the bowels.

In Group III, in which feces were inserted together with blood, a totally different picture was shown. Here the peritoneal cavity was found to be

normal, and free from adhesions. When it is borne in mind that quite a quantity of feces was spread at random over the bowels, this absence of adhesions was quite remarkable.

Clinical Application—As a result of these observations it was decided to apply this method to the treatment of peritonitis in human beings.

ILLUSTRATIVE CASE REPORTS

Case 1—A young man was brought into hospital with the history of a duodenal ulcer that had recently perforated. Immediate celiotomy was performed under spinal anesthesia, and a large perforation was found in the duodenum, and the whole abdominal cavity filled with gastric content and in a state of intense inflammation.

The perforation was closed by means of a large catheter that suitably filled the orifice, and some omentum was sutured around the perforation. At the close of the operation a catheter was placed at the corner of the wound which was then closed. An untied suture passing through both peritoneum and fascia was inserted at the angle of the wound where the catheter lay. Two hundred cubic centimeters of blood were withdrawn from the patient and were mixed with 30 cc of a 2 per cent sodium citrate solution. This blood was then run into the abdominal cavity and the catheter was withdrawn, and the loose suture tied. The patient made an uninterrupted recovery and has not since been troubled by the ulcer.

Case 2—An elderly man was brought into the hospital, with the history of a duodenal ulcer that had perforated six hours previously. Operation, under spinal anesthesia, disclosed a condition of severe peritonitis. The ulcer was treated as in Case 1, and again 200 cc of citrated blood were left in the peritoneal cavity. The patient had a smooth convalescence.

Case 3—A man, age 72, was admitted to the hospital, in a condition of ileus, with a history of vomiting, much abdominal pain and a very greatly distended abdomen.

Operation, under spinal anesthesia, showed an abdominal cavity filled with pus, a very necrotic appendix, and a condition of ileus. The appendix was removed, the abdomen closed without drainage and 200 cc of citrated blood were left in the abdomen. The patient made a very uneventful recovery, and left the hospital none the worse for his experience.

Case 4—A young man was brought into hospital with a gunshot wound of the abdomen and in a condition of considerable shock. Intravenous saline therapy was instituted and an immediate celiotomy was performed. The jejunum was ruptured in four places, and there was a large hole in the descending colon with the extrusion of much feces. The abdomen contained a large quantity of blood. This patient, some days later, developed a severe ileus which was treated with the Miller-Abbott tube and spinal anesthesia with complete success.

CONCLUSIONS

As a result of experiments carried out upon dogs and rabbits, the following conclusions were arrived at:

(1) Infection of the peritoneal cavity with a small quantity of fresh feces does not of itself tend to produce peritonitis. This was found to be the case in almost 100 per cent of the experiments.

(2) Infection of the peritoneal cavity with a small quantity of fresh feces together with exposure and trauma to the bowel wall, did tend to produce peritonitis in 90 per cent of the experiments.

(3) The injection of free blood into the peritoneal cavity increases the immunity of the peritoneum against infection by over 75 per cent

(4) The injection of free blood into the peritoneal cavity prevents the production of adhesion in a large percentage of cases

My thanks are due to Professor Saul Adler, of the Hebrew University, for his valuable advice, and in whose department many of these experiments were carried out Professor Bernard Zondek, also of the Hebrew University, very kindly permitted me to use his laboratories, and gave me much valuable advice

REFERENCES

- ¹ Issayeff Ztschr f Hyg u Infektionskrankh , 16, 287, 1894, Quoted by J A M A , October 30, 1937
- ² Steinberg Immune Cellular Reaction in Experimental Acute Peritonitis Arch Path , 8, 419, September, 1929
- ³ Steinberg Causes of Death in Acute Peritonitis Arch Surg , 23, 145, July, 1931, Am J Clin Path , 1, 6-253, May, 1936
Idem Protected and Unprotected Animals in Acute Peritonitis J Lab Clin Med , 20, 1180, August, 1935
- ⁴ Sparks Surg , Gynec , and Obstet , 48, 780, June, 1929

THE INTRAVENOUS USE OF SERUM AND PLASMA, FRESH AND PRESERVED*

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THE INTRAVENOUS USE of serum and plasma in place of whole blood is not new. The number of contributions on this subject has greatly increased in the last few years.

One of us has been interested in this problem intermittently since early 1927, at which time human serum was intravenously administered in cases of severe infections, especially those of streptococcic origin. It was noted then that the intravenous administration of serum in sufficiently large quantities (50 to 100 cc.) was commonly followed by reactions, often very severe, even when the sera were homologous, *i.e.*, caused no agglutination of the erythrocytes of the recipient. For serum, in this paper, is meant the fluid portion of the blood separated after clotting. Later (1929-1930), citrated blood was centrifuged and the plasma employed instead of serum. Primarily, this method was adopted because of its simplicity and its greater yield of the fluid portion. It was then noticed that the plasma, intravenously administered, caused no reactions, even when no attention was paid to typing. As a precaution the plasma was diluted with equal parts of saline solution before administration. We did not know at that time that this behavior of blood serum and blood plasma had already been observed and studied by Brodie,¹ as early as 1900. He found that, in cats and other experimental animals, the intravenous injection of blood serum, even autogenous, commonly produced reactions, which did not occur when similar quantities of sodium citrate plasma were used.

Of recent years, the intravenous injection of blood plasma in place of whole blood has been made the object of intense study by the Staff of the Bryn Mawr Hospital. Both serum and plasma have been used in infections,² in the prophylaxis and treatment of nutritional hypoproteinemia and anemias resulting therefrom,³ in burns,^{4, 5, 6} in certain hemorrhagic and hemolytic diseases, in preeclamptic states, in liver disease,⁷ in chronic colitis, and, finally, in secondary shock.⁸

It is not the purpose of this communication to evaluate the clinical results of the use of plasma in the various conditions enumerated nor to discuss the

* This investigation was aided by a special Research Fund established by the Women's Board of the Bryn Mawr Hospital. Submitted for publication February 12, 1940.

rationale of whole blood transfusion, but rather to emphasize the simplicity of preparation and the safety in its use as compared to whole blood, and to make certain comparisons with the use of serum, both fresh and preserved

The blood is collected in a closed system (Fig 1), employing as an anti-coagulant 2 per cent sodium citrate solution in saline in proportion of 100 cc for each 500 cc of blood. The citrate-saline solution is first drawn into a

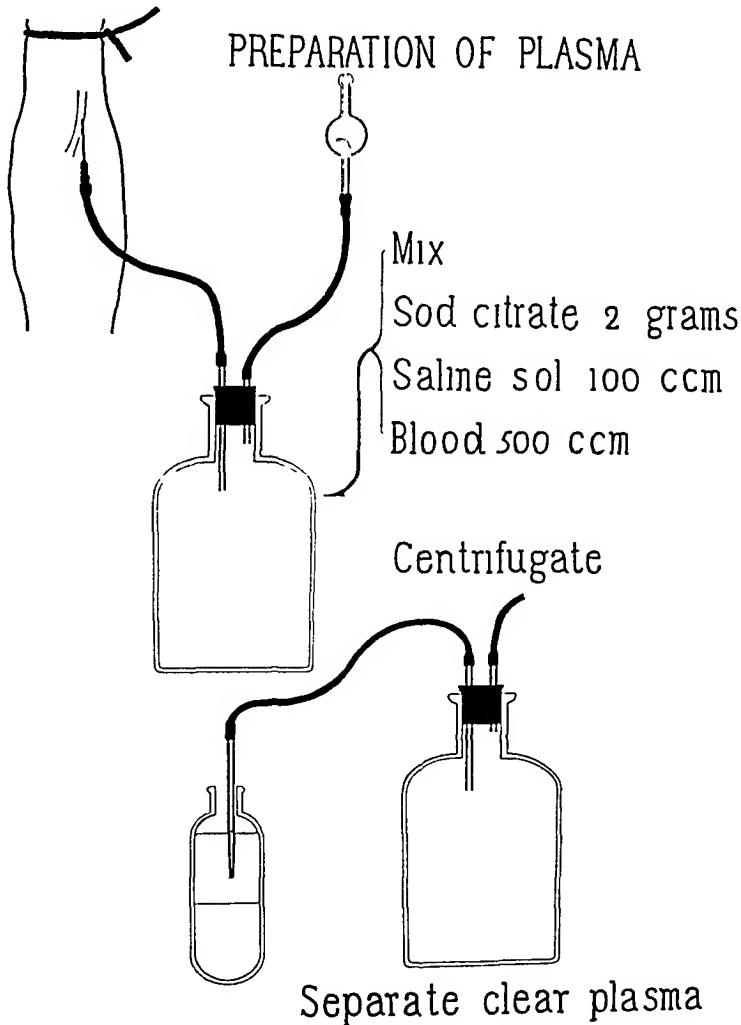


FIG 1—Showing the set up for the collection of blood by a closed system

liter pyrex flask by suction. The blood is then collected, using a rather large needle (No 15-16 gauge) with the aid of slight suction. The flask is gently and continually rotated during collection, to insure thorough mixing of the blood with the citrate-saline solution. The plasma is separated by centrifuging the citrated blood for about one-half hour at high speed (2,000 r p m). When considerable quantities of plasma are to be prepared, it is convenient to use a large centrifuge, holding four 250 cc rubber-capped glass containers. The

opalescent supernatant plasma is removed by suction in a closed system and is stored at 4° C. The average yield of plasma is a little over 50 per cent of the citrated blood employed, not including the added citrate-saline solution. If the plasma is to be kept more than one day before being used, it is advisable to add "Merthiolate" 1:10,000 as preservative. On standing, there occurs, at times, a flocculent precipitate which is readily removed by short centrifugation. It does not, however, cause reactions if not removed. If the blood is collected after a meal, a buff layer of lipid substance will, on standing, rise to the surface of the plasma. This material need not be removed, as it causes no reactions, and is easily resuspended by gentle shaking before administration.

Contrary to the statement of Lehman,⁹ and others, it is not necessary, in our experience, to type the citrated plasma prior to the intravenous administration. Elliott¹⁰ reached the same conclusion. As a rule we dilute the plasma with equal parts of saline or saline-glucose solution before injection, and regulate the speed of administration from 5 to 10 cc per minute. When for particular reasons the bulk of fluids is to be limited, undiluted plasma may be safely administered. In such cases we regulate the speed of injection not to exceed 5 cc per minute. The speed of administration does not seem to be, within certain limits, an essential factor, unless there exists a clinical contraindication. Undiluted plasma has been given in emergency cases at the rate of 8-10 cc per minute without reaction. Viscosity of the material prevents administration at greater speed when the usual gravity method and a small size needle (No. 19-20 gauge) are employed.

Plasma thus administered has proved its complete safety and absence from reactions in over 1,500 administrations. One very important feature is that it can be given in very large and repeated doses. In one instance as much as 7,300 cc were given in 11 days to a patient with severe burns, in an effort to maintain the serum protein concentration of the blood at a normal level. As much as 950 cc of undiluted plasma were given as a single dose, followed immediately by 450 cc of whole blood, without reaction. Intravenous injections of citrated plasma, fresh and preserved, have been repeated at intervals of three weeks, or longer, without reaction.

In 1935, Elser, Thomas and Steffen,¹¹ and, later, Flosdorf and Mudd¹² published reports on the procedure for the preservation in the lyophile form of serum and other biologic substances. Serum preserved in the lyophile form has been employed intravenously following regeneration with sterile water in the treatment of nephrosis by Aldrich, *et al*,¹³ and Jeans,¹⁴ for the reduction of increased intracranial pressure by Hughes, *et al*,^{15a, b} and in hypoproteinemias by Ravdin.³ It has been suggested from experimental work upon animals by Bond and Wright,¹⁶ that the use of regenerated lyophile serum would be of benefit in hemorrhage and traumatic shock. Mahoney,¹⁷ employing lyophilized plasma, reached the same conclusion after similar experiments. Thompson, *et al*,¹⁸ used lyophilized plasma to prevent hypoproteinemias and wound disruption in experimental animals.

Intravenous administration of lyophilized serum is often followed by reactions. Thus, Aldrich, *et al*,¹³ noted reactions to intravenous administration of lyophilized serum, which in two out of nine cases were severe and accompanied by chills and high temperature. Lehman⁹ reported reactions with similar material, as does Ravdin.³ In our experience, the intravenous administration of lyophilized serum has often been accompanied by severe reactions, even with as little as a 5 cc dose. These reactions have been generally attributed to a change induced in the serum by the lyophile process. Our experience with fresh serum, related above, led us to investigate the use of lyophilized plasma. Citrated plasma, separated in the manner above mentioned, and lyophilized by the method of Flosdorf and Mudd,¹⁹ was regenerated with sterile water to restore its original volume and administered intravenously to patients in quantities up to 100 cc without reactions. This material was then employed in greater quantities in isotonic form and also in the hypertonic form, *ie*, concentrated as much as five times, still without reaction. The following is an abstract of a typical case.

Case Report—A white woman, age 82, weighing 63 Kg, was admitted to Bryn Mawr Hospital with amebic dysentery. During the convalescence the patient developed hypo-albuminemia, with generalized pitting edema and oliguria. She was given, intravenously, citrated, lyophilized plasma regenerated with distilled water to only one-fifth of its original volume (125 cc, corresponding to 625 cc of undiluted plasma). The lyophilized material had been preserved for several months. The plasma was administered by the drip method, during a period of 20 minutes. There was no reaction. The urinary output exceeded the intake for a period of three days following the administration of plasma. Within 48 hours, the edema had disappeared and in six days, when again checked, the blood albumin concentration rose from 2.6 Gm per cent to 3.2 Gm per cent.

In other cases, concentrated lyophilized plasma was administered at even greater speed, up to 110 cc of five times concentrated solution (corresponding to 550 cc of undiluted citrated plasma) in six minutes, without reaction. It is to be noted that concentrated lyophilized plasma appears as an opaque, amber, viscid fluid and that, to obtain the speed of transfusion mentioned above, a syringe must be used. We do not advocate rapid administration except in emergency cases, but we report it to emphasize the safety of the material. The method of choice for injection is the drip method, at a rate of about 4–5 cc per minute.

COMMENTS AND DISCUSSION—It may be accepted as a fact that intravenous administration of serum, fresh or preserved by the lyophile process, is often followed by severe reactions. These reactions were not encountered, in our experience or in that of other workers, *etc*,^{4 5 10 20} when citrated plasma, separated by centrifugation, is employed, fresh or preserved, either by refrigeration or by the lyophile process. We do not intend to discuss the physicochemical differences between the serum and plasma responsible for the mentioned difference in behavior. We may assume, with Brodie,¹ that the difference is brought about by the process of fibrin precipitation. Reactions often

occur when citrated blood in which, accidentally, clotting has taken place, is injected intravenously. Filtration to eliminate blood clots does not prevent reactions.²⁶

It is unfortunate that, in many reports, the terms "serum" and "plasma" appear to be used interchangeably. For instance in the article of Mahoney,¹⁷ Bond and Wright¹⁶ are quoted as having employed lyophilized plasma. Bond and Wright used lyophilized serum only in their investigative work.²¹ Similarly, McClure⁶ appears to use the two terms interchangeably.

In the ordinary type of hospital the lyophilizing of plasma is not necessary, due to the fact that plasma keeps well under ordinary conditions of refrigeration (about 4° C) for several months, except when used for its prothrombin and complement content. The content of specific antibodies in the plasma remains unchanged for at least 32 days,²² the complement activity begins to decline only after the third and fourth week,²² in a manner similar to that reported for refrigerated blood.²³ The period of useful survival of prothrombin was found to be one week to ten days,²² similar to that found for the refrigerated blood by Rhoads,²⁴ and Loid.²⁵

Plasma preserved at 4° C has been employed successfully after 40 days, in the treatment of secondary shock⁸ and various forms of hypoproteinemias. It is presumed that blood plasma can be preserved by refrigeration for much longer periods of time. Thus, plasma has been kept for three to four months in the frozen state, and then employed intravenously, without reaction. Refrigeration at 4° C is probably as effective as freezing as a means of preservation, but technically much simpler.

In the Bryn Mawr Hospital, the plasma is a by-product of the blood bank. Experimental data²² suggest that refrigerated blood is useless, occasionally dangerous, after five days of preservation. Citrated blood after five days of storage is centrifuged, the plasma pooled, dated and preserved. This keeps a fresh supply on hand for use in the conditions outlined previously. The lyophile method of preservation would, obviously, be of value in isolated hospitals, in cases of emergency in outlying districts, involving field work, disasters of many sorts, such as fires, flood, earthquakes, war, *etc.*^{20, 27} and for cases in which hypertonic plasma is indicated. We have employed lyophilized plasma kept for a period of ten months without reactions, it can, in all probability, be kept for a much longer period of time.

CONCLUSIONS

The intravenous use of citrated blood plasma without cross-matching is both safe and convenient. This applies to fresh plasma, or plasma preserved by either refrigeration at 4° C or the lyophile process. Serum, separated after clotting, may cause reactions, often severe, when intravenously injected, whether employed fresh or preserved by either refrigeration or the lyophile process.

Appreciation is expressed to the Staff of the Bryn Mawr Hospital for their helpful cooperation and, especially, to Dr. D. D. Bond for valuable aid.

REFERENCES

- ¹ Brodie, T G The Immediate Reaction of an Intravenous Injection of Serum Jour Physiol, 26, 48, 1900
- ² Nicholson, P Notes on the Treatment of an Unusual Case of Hemolytic Streptococcus Septicemia Jour Ped, 8, 363, 1936
- ³ Ravdin, I S, Stengel, A, Jr, and Prushankin, M The Control of Hypoproteinemia in Surgical Patients J A M A, 114, 107, 1940
- ⁴ Elkinton, J R, Gilmour, M T, and Wolff, W A The Control of Water and Electrolyte Balance in Surgical Patients ANNALS OF SURGERY, 110, 1050, 1939
- ⁵ Elkinton, J R The Systemic Disturbances in Severe Burns and Their Treatment Bull of the Ayer Clin Lab Penna Hosp, 3, 279, 1939
- ⁶ McClure, R D The Treatment of the Patient with Severe Burns J A M A, 113, 1809, 1939
- ⁷ Tumen, H J, and Bockus, H L The Clinical Significance of Serum Protein in Hepatic Disease Am Jour Med Sci, 193, 788, 1937
- ⁸ Strumia, M M, and Wagner, J A The Use of Citrated Plasma in the Treatment Secondary Shock, J A M A, May, 1940
- ⁹ Lehman, E P A Simple Method of Plasma Transfusion J A M A, 112, 1406, 1939
- ¹⁰ Elliott, J A Preliminary Report of a New Method of Blood Transfusion South Med and Surg, 98, No 12, 643, 1936
- ¹¹ Elser, W J, Thomas, A R, and Steffen, G I Desiccation of Sera and Other Biologic Products, Including Microorganisms, in the Frozen State, with Preservation of the Original Qualities of Products So Treated Jour Immun, 28, 433, 1935
- ¹² Flosdorf, E W, and Mudd, S Procedure and Apparatus for Preservation in Lyophile Form of Serum and Other Biologic Substances Jour Immun, 29, 389, 1935
- ¹³ Aldrich, C A, Stokes, Jos, Jr, Killingsworth, W P, and McGuinness, A C Concentrated Human Blood Serum as a Diuretic in the Treatment of Nephrosis J A M A, 11, 129, 1938
- ¹⁴ Jeans, P C The Use of Lyophile Serum Jour Iowa St Med Soc, 29, 64, 1939
- ^{15a} Hughes, Jos, Mudd, S, and Strecker, E A Treatment of Increased Intracranial Pressure by Concentrated Human Lyophile Sera Trans Am Neurol Assn, 62, 118, 1936
- ^{15b} Hughes, Jos, Mudd, S, and Strecker, E A Reduction of Increased Intracranial Pressure by Concentrated Solution of Human Lyophile Serum Arch Neurol and Psych, 39, 1277, 1938
- ¹⁶ Bond, D D, and Wright, D G Treatment of Hemorrhage and Traumatic Shock by the Intravenous Use of Lyophile Serum ANNALS OF SURGERY, 107, 500, 1938
- ¹⁷ Mahoney, E B A Study of Experimental and Clinical Shock with Special Reference to Its Treatment by the Intravenous Injection of Preserved Plasma ANNALS OF SURGERY, 108, 178, 1938
- ¹⁸ Thompson, W D, Ravdin, I S, Rhoads, J E, and Frank, I L Use of Lyophile Plasma in Correction of Hypoproteinemia and Prevention of Wound Disruption Arch Surg, 36, 509, 1938
- ¹⁹ Flosdorf, E W, and Mudd, S An Improved Procedure and Apparatus for Preservation of Sera, Microorganisms and Other Substances—The Cryochem Process Jour Immun, 34, 469, 1938
- ²⁰ Brodin, P, and Saint Guons, F Plasma Transfusion J A M A, 113, 2072, 1939
- ²¹ Bond, D D, and Wright, D G Personal communication, 1939
- ²² Strumia, M M The Fate of Transfused Refrigerated Blood (In course of publication)

- ²³ Kolmer, J A Preserved Citrated Blood "Banks" in Relation to Transfusion in the Treatment of Disease with Special Reference to the Immunologic Aspects Am Jour Med Sci, 197, 442, 1939
- ²⁴ Rhoads, J E Prothrombin Time of Bank Blood J A M A, 112, 309, 1939
- ²⁵ Lord, J W, and Pastore, J B Plasma Prothrombin Content of Bank Blood J A M A, 113, 2231, 1939
- ²⁶ Wiener, A S Blood Groups and Blood Transfusion Charles C Thomas, Baltimore, 1935
- ²⁷ Tatum, W L, Elliott, J, and Nessett, N A Technique for the Preparation of a Substitute for Whole Blood Adaptable for Use during War Conditions Military Surgeon, 85, 481, 1939

FUNDAMENTAL FACTORS GOVERNING LYMPHATIC SPREAD OF CARCINOMA

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THE LYMPHATIC spread of carcinoma is generally spoken of as a permeation or embolism through an afferent lymph channel, involvement of the lymph node, spread through the node into the efferent lymph channel, and a repetition of the process through nodes until the thoracic duct is reached. Sampson Handley,¹ studying advanced lesions, was an advocate of the permeation theory. Ewing² recognizes the process of permeation but maintains that much of the spread must be by embolism. An important surgical aspect of this question is the manner of spread, once a node is involved, and the significance of finding involved nodes at the time of operation.

A very careful study of the lymph node metastases in 74 operative specimens of carcinoma of the rectum and colon was made. This was done by clearing the specimens as described (Gilchrist and David)³. Full scale drawings of all specimens with the arterial tree and the exact location of the lymph nodes in relation to the tumor and arteries were made. About 3,500 different lymph nodes were studied and microscopic sections were made. Three hundred sixty-four of these nodes contained carcinoma metastases. In addition, Dr. C. W. Monroe has allowed me to review 651 microscopic sections of lymph nodes studied in a similar fashion in operative specimens of carcinoma of the breast. There were 118 of these nodes which contained metastases. A study of our material has led me to the conclusion that the lymphatic spread of carcinoma is primarily embolic, and that the nodes where emboli lodge prevent further spread until the node is completely overwhelmed by carcinoma. Further embolic spread is through the collateral lymph channels, each new node involved tending to make a longer channel for a new embolus to travel. Spread from one node to another is not common, at least during the period when lesions are seemingly operable.

In order to understand the factors governing the spread of carcinoma through the lymphatic system, let us examine its structure. The lymph is collected into thin-walled elastic channels which run for a variable distance from their origin in the structure to be drained to the lymph nodes. The nodes and lymph channels tend to lie in close proximity to the blood vessels supplying the region. The nodes are made up of a capsule, thick or thin, or the small nodes of the mesentery may have no capsule, but there does seem to be a definite boundary between the lymphoid tissue and the surrounding fat. In those nodes containing a capsule the collecting lymph channels pierce the capsule and discharge their contents into the subcapsular space which lies between the capsule and the lymphoid tissue. The center of the node has a connective

tissue framework, the reticular cells. The larger nodes are divided into gross compartments by connective tissue trabeculae leading from the capsule to the hilus of the node. The lymph cells are found between the reticular cells. There are many collecting lymph channels entering each node. I have repeatedly made injections directly into ten to 14 different afferent channels entering one node in a dog's mesentery. These, of course, all empty into the subcapsu-

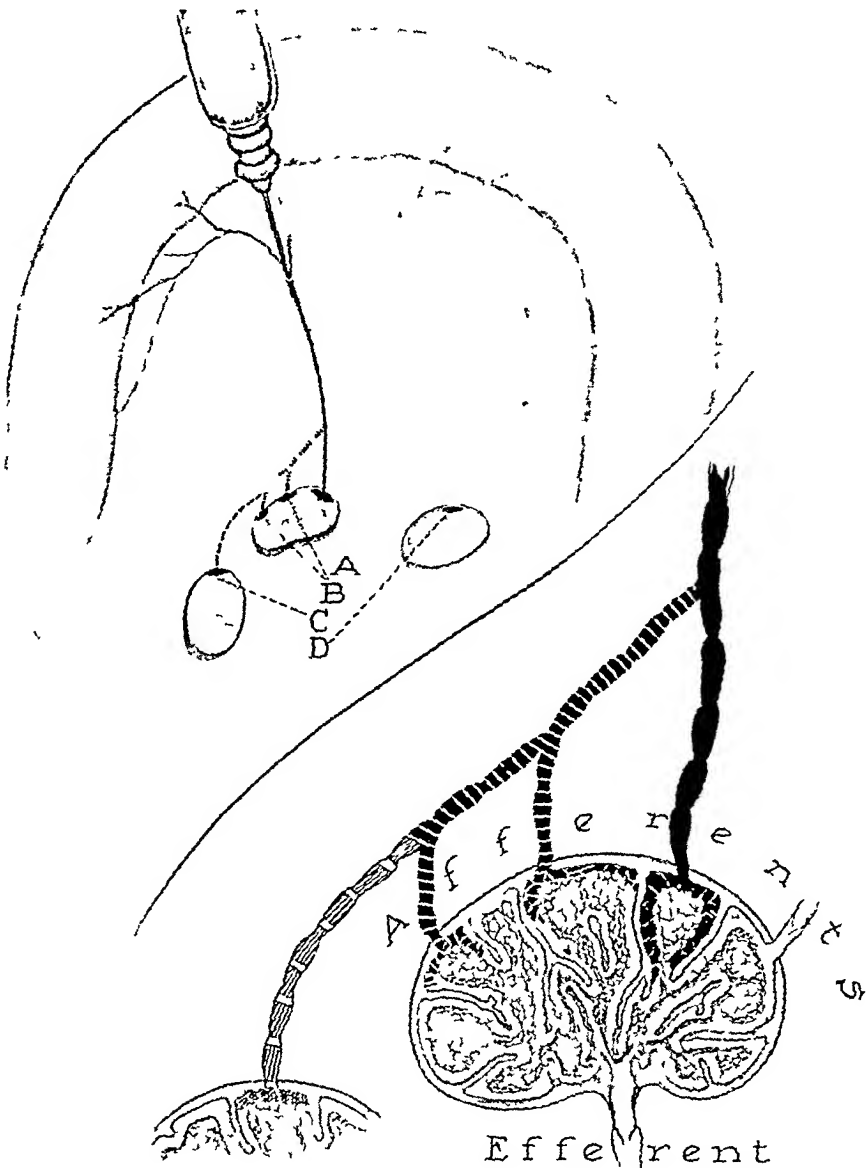


FIG. 1.—Showing the manner of spread of a suspension of insoluble particles injected into a single afferent lymph channel

lar space. Many large afferent lymph channels break up into two, three, or more short channels just outside the node, and then these shorter channels pierce the capsule to empty into different parts of the subcapsular space, or one of the short channels may empty into the lymph sinus of an adjoining node. In addition, there are usually several different anastomosing channels between the large afferent channels draining a given region of the bowel, and the channels draining into adjacent nodes on either side (Fig. 1)

When a colored solution is injected into an afferent lymph channel of a dog's or rabbit's mesentery, using very low pressure, the solution will penetrate through the node without coloring all of it. The node seems to be divided grossly into separate anatomic units so that material from a given channel seems to drain to a limited part of the node. When pressure is used in the injection, the entire node will be colored before any dye appears in the efferent channel. If, instead of a colored solution, a suspension of carbon particles $\frac{1}{2}$ to $1\ \mu$ in diameter, or of silica which is less than $\frac{1}{2}\ \mu$ in diameter, or a suspension of barium or carmine particles is used to inject into the afferent

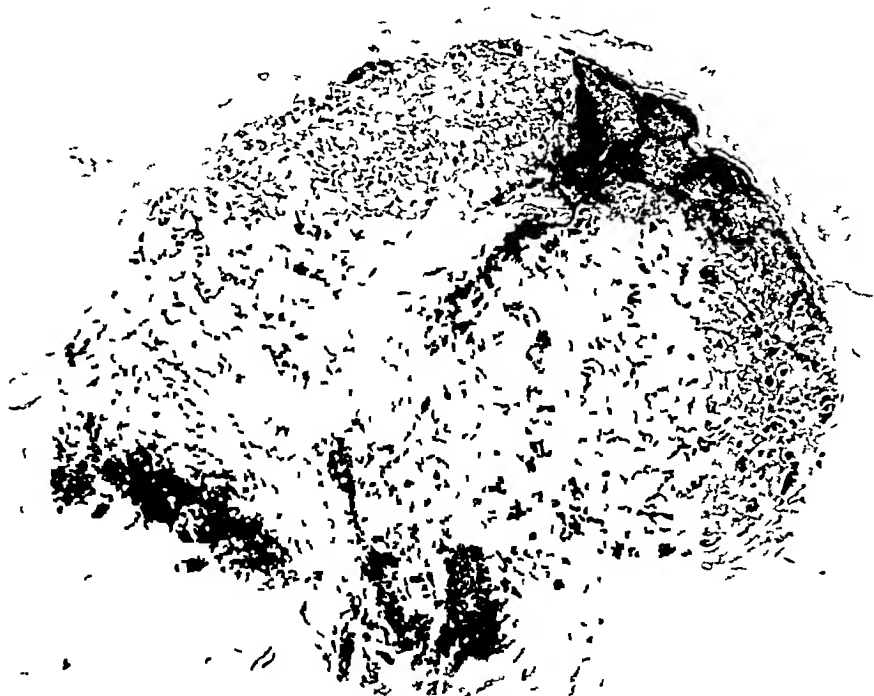


FIG. 2.—Photomicrograph of lymph node almost completely replaced by carcinoma metastases. The normal parts are seen as dense finely granular areas. A suspension of carbon particles was injected into the lymph channels in the neighborhood of the carcinoma of the breast. Most of the carbon is seen in the normal part of the node although some of it penetrates a short distance along spaces between the cancer cells. A part of the lymph sinus which is involved with carcinoma also contains carbon particles. Two areas of fatty degeneration are seen.

channel using very low pressure, a different picture is seen. The suspension of colored particles will partially fill its own compartment in the subcapsular space (Fig. 1 A). If more pressure is used, the suspension will either overflow into the remainder of the node or it will enter the adjacent parts of the node through one of the short channels leading into a different part of the subcapsular space (Fig. 1 B). If there is much pressure, the node is soon a solid black and the suspension may pass into one or even two or three of the adjoining nodes through the short channels (Fig. 1 C). At the same time it may back up one of the tributary channels emptying into the original channel injected and it is often possible to get it to go through a retrograde anastomosing channel and come through another afferent channel into an adjoining normal node (Fig.

1 D) Even great pressure to the point of rupturing the walls of the afferent channels will not force any one of the fine suspensions through the node. If the animal is killed immediately or is allowed to live for a week and then killed, no sign of passage through any node is seen, either in transparent preparations or in microscopic sections.

This demonstration of the collateral drainage is made easier by blocking the afferent channels of one node with sodium morrhuate three or four days before injection with the colored suspension. The blockage will cause a dilatation of the collateral channels. This experiment shows very graphically

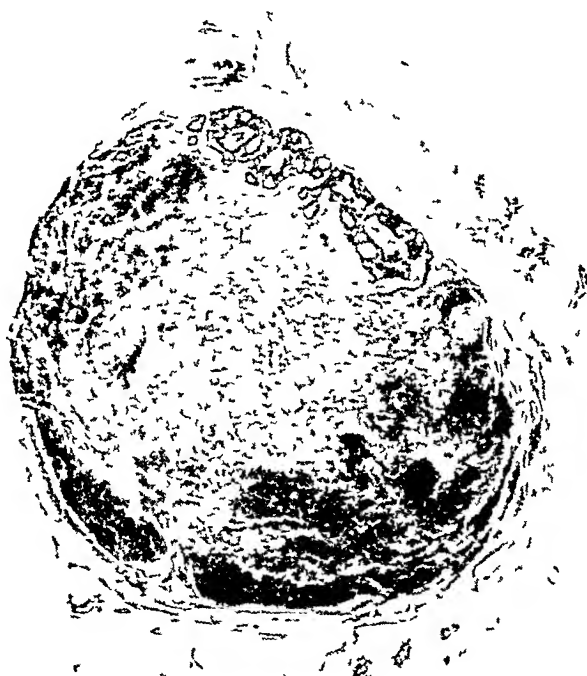


FIG. 3.—Photomicrograph of a carcinoma metastasis confined to the subcapsular space. The thickened capsule over the region of the metastasis is clearly seen.

how, when a node is destroyed or blocked, the lymph drainage is rerouted through collateral channels, or by retrograde means, into a channel draining into a normal node. Carcinoma cells are $7\ \mu$ or more in diameter in contrast to these particles, which were all less than $1\ \mu$ in diameter. The normal system of collateral lymph channels, plus the demonstration of retrograde channels available when nodes are blocked, shows how much more likely spread of the large carcinoma cells is apt to be by collateral channels than by growth through lymph nodes.

A study of our surgical material has brought out the following facts:

(1) Permeation of carcinoma through lymph channels was seen only when the lymph node central to the channel involved was already blocked with carcinoma.

(2) Carcinoma metastases do not completely destroy the function of a node until all of the node is destroyed. This was shown in a surgical specimen of carcinoma of the breast. The lymph channels in the neighborhood of the

tumor were injected with a suspension of carbon particles. The specimen was cleared and some of the lymph channels and several lymph nodes were seen to be outlined in black. This section shows how the carbon suspension could still flow into a node which contained a large metastasis. Most of the carbon is found in the normal part of the node although some of it penetrates a short distance along spaces between the cancer cells (Fig 2)

(3) Forty-four of the 364 carcinomatous nodes contained metastases limited to the subcapsular space just beneath the capsule (Fig 3). In 150 of the 364 involved nodes, the lymphoid tissue was completely replaced by carcinoma.

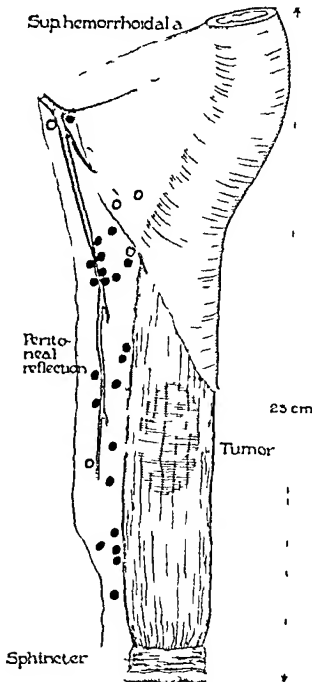


FIG 4—Path No 33779
Operative specimen showing almost complete occlusion of superior hemorrhoidal artery by a mass of necrotic carcinomatous nodes. In some of the tightly packed nodes the carcinoma had penetrated through the capsule.

(4) Throughout the entire series a common pattern of lymph node metastasis was seen. When the metastasis has grown larger than the small subcapsular lesion, the spread is by expansion around the subcapsular space and into the depth of the node. This is usually accompanied by a thickening of the capsule especially over the area adjacent to the growth. There may be a more or less heavy layer of fibrous tissue between the cancer cells and the lymph cells. In many cases there is so much interference with nutrition that we see a thick layer of fibrous tissue, a thin rim of live cancer cells within this, and necrosis in the center. Growth progresses until we see one or several large nodes, usually lying close to the main blood vessels, in which the lymphoid tissue is completely replaced by carcinoma. Groups of lymph nodes which are completely replaced by metastases tend to be found in certain regions. In specimens of carcinoma of the rectum and lower sigmoid such nodes are usually located near the bifurcation of the superior hemorrhoidal artery (Fig 4). In carcinoma of the breast, nodes about one inch below the brachial vein and along the lateral edge or just behind the pectoralis minor muscle are the ones most

likely to be completely replaced by carcinoma. The group of heavily involved nodes is along the main or primary line of lymph drainage. Nodes involved below or lateral to these nodes are apt to be subcapsular lesions or ones which are obviously late metastases.

(5) In no case has there been any evidence of penetration of carcinoma outside of the capsule of any node, except where there was a collection of large involved nodes lying tightly packed together. In seven of the nine cases where this occurred, the superior hemorrhoidal artery or the main artery supplying the region of the nodes was blocked by pressure of the nodes. Several of these nodes contained necrotic material.

(6) In six cases, retrograde metastasis of lymph nodes was found below

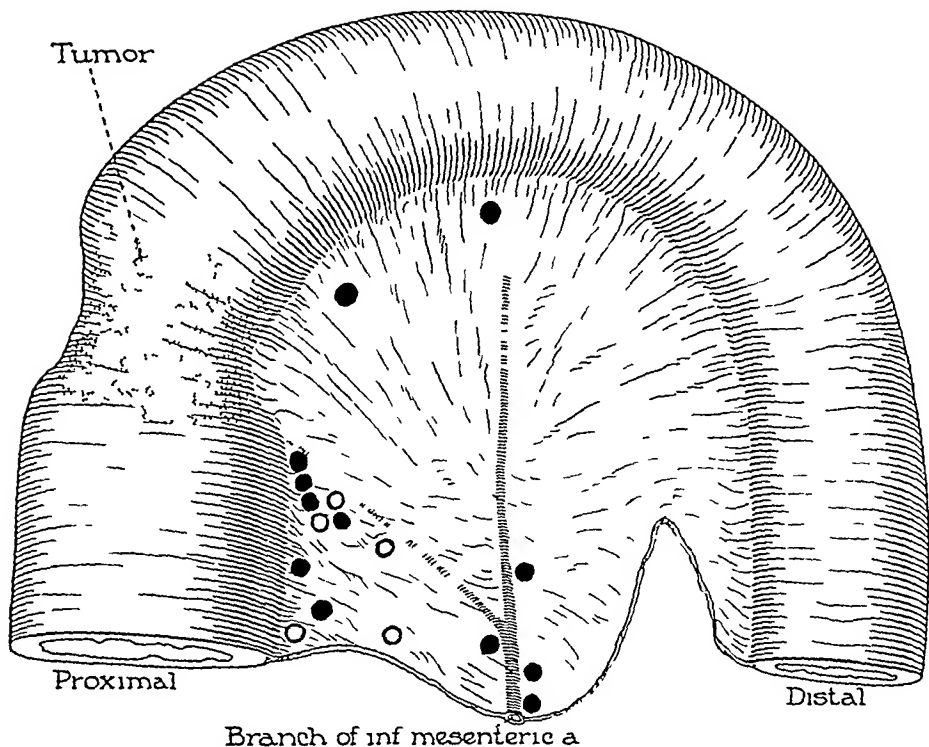


FIG 5—Path No 33730 Example of extensive metastases to central lymph nodes, apparent lymph blockade, and metastasis in a retrograde manner to a node distal to the lesion

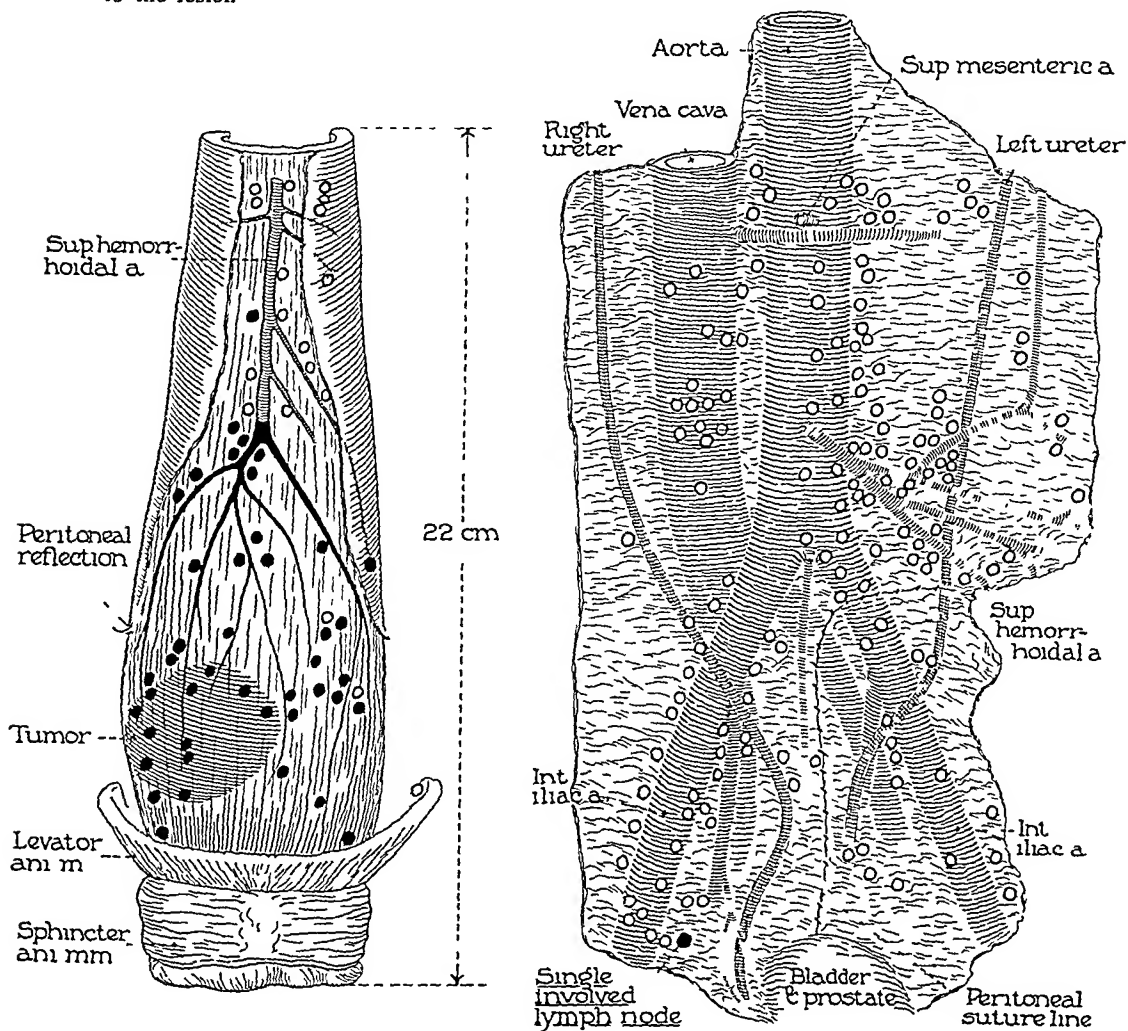


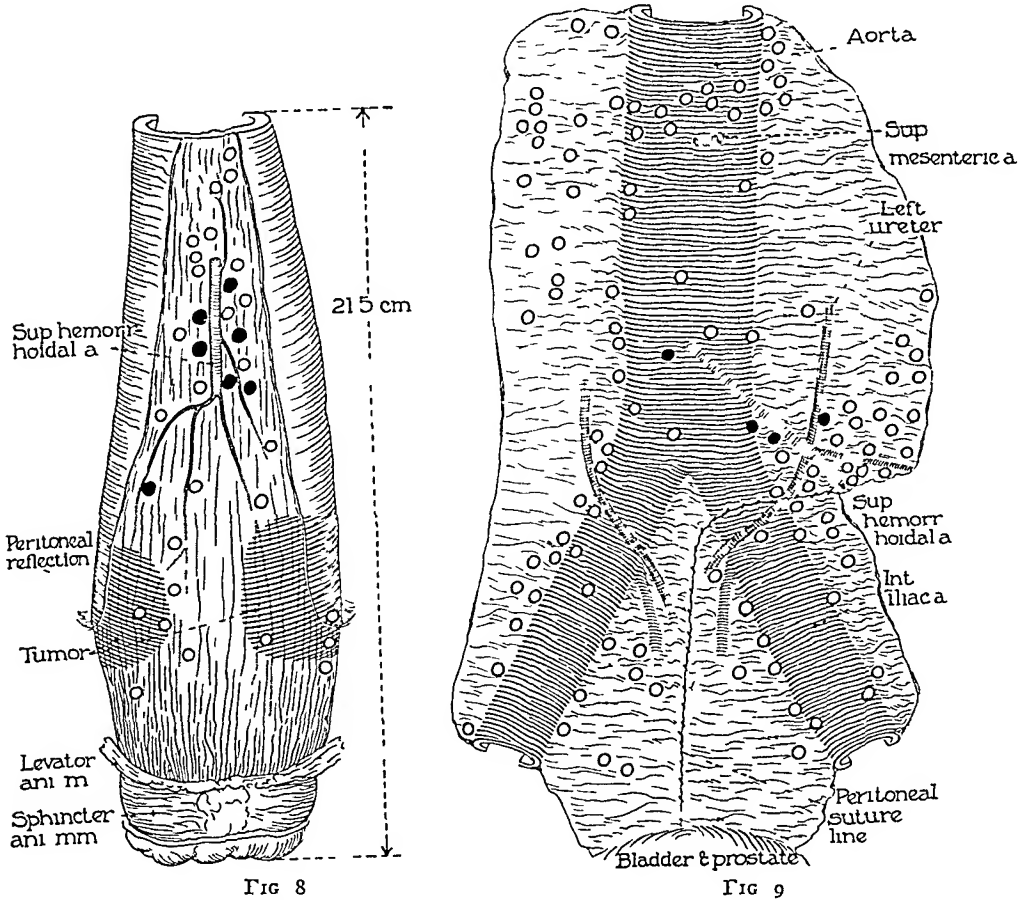
FIG 6

FIG 7

FIGS 6 and 7—Path No 36303 Figure 6 Operative specimen of carcinoma of the rectum showing extensive lymph node metastases above the tumor and diagram of the autopsy preparation showing limitation of the upward metastasis Figure 7 The one node involved was just outside of the operative field—and it was a small subcapsular lesion

carcinomata of the bowel or rectum. In every one of these enough of the nodes central to the lesion were completely replaced by carcinoma to make us feel certain that there was a very marked obstruction to lymph flow and the metastasis was by retrograde means (Fig 5)

(7) Postmortem examination of surgical patients demonstrates the tendency of the lymph nodes to block the spread of carcinoma even in advanced cases. In four cases, where the patients died within two weeks after resection of the rectum or sigmoid for carcinoma, microscopic sections were made of all



FIGS 8 and 9.—Path No 36642. Figure 8. Operative specimen of extensive high lying lymph node involvement, and autopsy preparation. Figure 9. The three nodes near the line of resection of the superior hemorrhoidal artery could not be resected at this site because of a congenital peritoneal anomaly. The highest node involved showed only a small subcapsular metastasis.

of the retroperitoneal nodes from above the point of origin of the superior mesenteric artery to the inferior border of the prostate, as far distal as it is possible to cut the arteries from within the abdomen. Each of these preparations contained 110 to 168 lymph nodes. The one patient who had no metastases in his operative specimen also had none in the 110 abdominal nodes examined. In the second patient (Fig 6) 43 of the 62 nodes found in the surgical specimen contained metastases. In spite of the extensive lymph node involvement in the operative specimen (Fig 7), there were no metastases above the point of resection. The one node involved was about 1 cm lateral to the widest point of resection, along the superior surface of the levator ani

muscle This is the second route of lymphatic metastasis in carcinoma occurring at the level of the levator ani muscle The third patient was a man 72 years of age There were a number of enlarged nodes high up (Fig 8) Because of a peculiar congenital peritoneal anomaly the superior hemorrhoidal artery could not be resected as high as it usually is Thirty-five nodes were

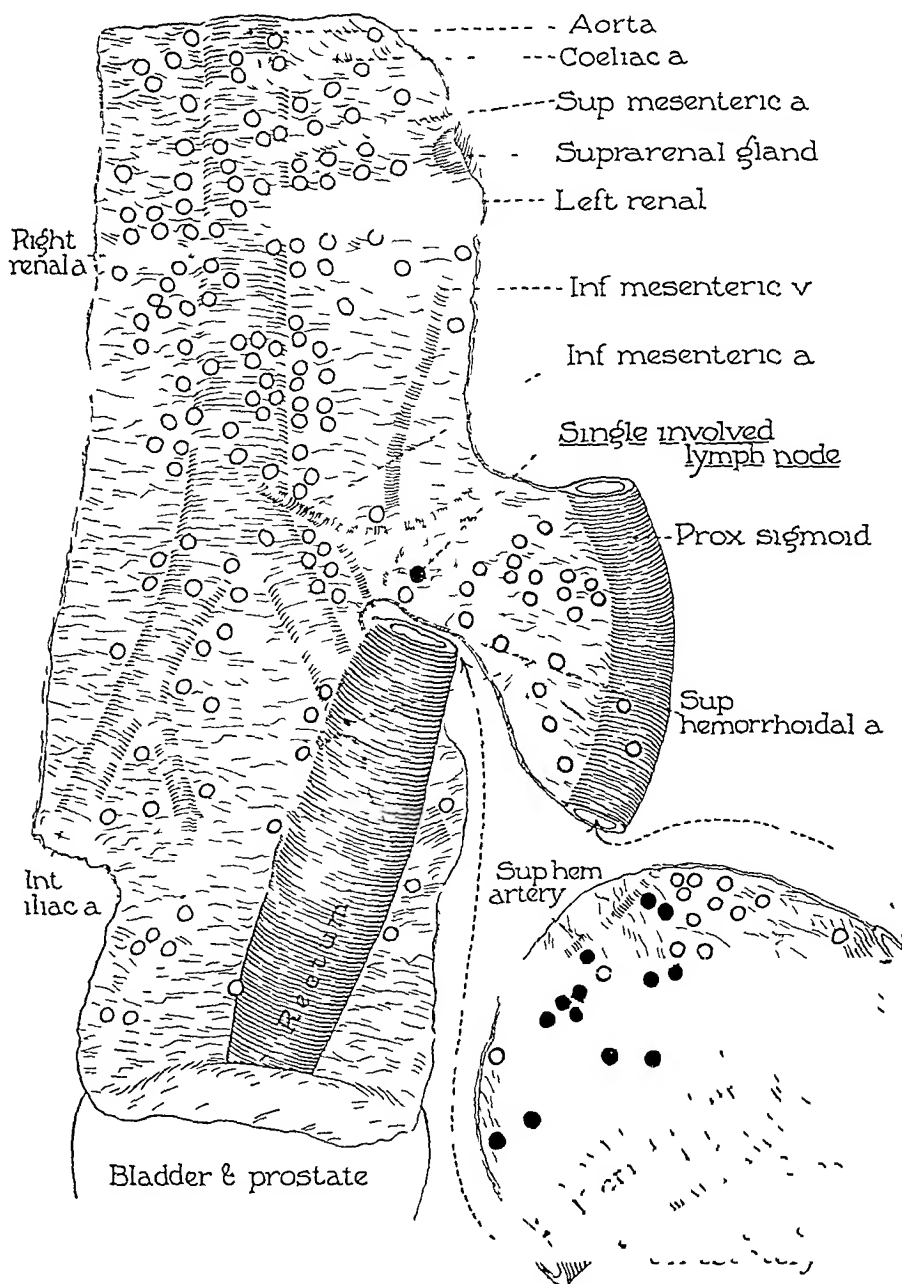


FIG 11

FIG 10

FIGS 10 and 11—Path No 37719 Figure 10 Operative specimen of carcinoma of the rectosigmoid having a very large mass of involved nodes close to the line of resection Figure 11 Autopsy specimen showing a small subcapsular metastasis in a node just beyond the line of resection

found in the operative specimen, seven of them contained carcinoma The diagram of the postmortem preparation (Fig 9) shows the location of the 111 nodes studied The four nodes found to be involved at postmortem are marked The three nearest the tumor were heavily involved with carcinoma

and would probably have been removed except for the congenital anomaly. The fourth postmortem specimen was from a man 66 years of age. The lesion was just above the rectosigmoid. It was the size of a fist and there was a large mass of nodes up to the promontory of the sacrum. A David⁴ type of obstruction resection was performed (Fig 10). Many of the involved nodes seen near the highest point of resection were completely destroyed by carcinoma (Fig 11). Only one of the 168 nodes found in the postmortem preparation contained carcinoma, and that was a very small subcapsular metastasis. None of these four patients had demonstrable metastases either in the liver, lungs or elsewhere at postmortem.

CONCLUSIONS

(1) The normal lymph node of a rabbit or dog will not pass a suspension of insoluble particles $1\ \mu$ or less in diameter even when pressure of 120 cm of water is used. The coloring of a number of adjacent nodes by the particles following injection into a single afferent lymph channel is explained by the anatomic distribution of collateral or retrograde lymph channels.

(2) Permeation of carcinoma through lymph channels is not the usual manner of spread in early lesions.

(3) Nodes partially involved by carcinoma may still function.

(4) Many metastases to lymph nodes are confined to the subcapsular space.

(5) Groups of lymph nodes involved with advanced metastatic lesions tend to be found in certain regions. Retrograde metastases are found only when the nodes in these regions are heavily involved. Metastases in nodes below or lateral to the main lymph drainage are apt to be subcapsular lesions or obviously late metastases.

(6) Spread of carcinoma through the capsule of a node is rarely seen in surgical specimens, and then only in lesions having a mass of heavily involved nodes packed together. The blood supply to the nodes is usually interfered with in such cases.

(7) Postmortem examination of surgical patients demonstrates the tendency of the lymph nodes to block the spread of carcinoma even in advanced cases.

All of these facts lead us to the conclusion that the lymphatic spread of carcinoma is primarily embolic. The nodes where the emboli lodge prevent further spread until the node is completely overwhelmed by carcinoma. Further embolic spread is through the collateral channels, each new node involved tending to make a longer and more difficult channel for a new embolus to travel. Spread from one node to another does not seem to be common, at least during the period when lesions are operable. Thus the finding of a group of involved nodes within the field removable by surgery does not mean that such a case is hopeless, although the chance of complete removal is much less than in those where such nodes are not found.

REFERENCES

- ¹ Handley, Sampson Cancer of the Breast Paul B Hoeber, New York, 1922
- ² Ewing, James Neoplastic Diseases W B Saunders Co, Philadelphia, 1931
- ³ Gilchrist, R K, and David, Vernon C Lymphatic Spread of Carcinoma of the Rectum
ANNALS OF SURGERY, 108, 621, October, 1938
- ⁴ David, Vernon C Treatment of Carcinoma at the Rectosigmoid Junction by Obstruction Resection Surg, Gynec and Obstet, 59, 491, September, 1934

METABOLIC AND BLOOD CHEMICAL CHANGES IN A SEVERE BURN

CASE REPORT

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INASMUCH as few complete chemical and metabolic studies have been made clinically in severe burns, the following case report seems of significance

Case Report—The patient, white, male, age 27, was severely burned by gasoline which exploded, setting fire to his clothes. A local physician immediately sprayed the burned area with tannic acid. He also received numerous hypodermics for pain as well as moderate amounts of whisky. He was admitted to the St Louis City Hospital, 48 hours later, January 3, 1938, on the third day after the accident. During his first month's hospitalization, he had the services of three special nurses, which enabled an accurate measurement of intake and output, much of this data is presented in Chart 1. Further details of his course and treatment are described herewith. Although this report represents only 30 days of his illness, the patient remained in the hospital for several months but eventually made a complete recovery. Most of his later therapy concerned the skin grafting of the burned area.

Clinical Course—The patient was conscious and rational on entrance and remained so until the sixth day after the accident. The blood pressure was 150/110 on the seventh day and reached the high mark of 182/120 on the twelfth day. It remained about 160/120 until the nineteenth day when it suddenly dropped to 130/80 and then stayed there except for an occasional rise to 150/90. From the sixth to the seventeenth day he was more or less drowsy most of the time, and vomited one or more times every second or third day. He became comatose on the twelfth day. Muscle twitchings were observed on the eighth and twelfth days. Cheyne-Stokes breathing was noted on the twelfth day. With the high blood pressure on this day, the clinical picture was that of "pseudo-uremia." The patient became rational and alert on the seventeenth day and remained so from then on.

It was estimated that about 40 per cent of his body had been burned, i.e., the entire circumference of both legs up to the groin, both buttocks, a small part of the lower abdomen and the distal thirds of both arms. Nearly all of the burn was third degree as shown by the granulating areas which were eventually revealed under the crust. Indeed, in many places over the thighs fascia lata and muscle were involved. The tanned areas were gradually debrided whenever infection was evident or suspected. The débrided, granulating areas were covered with saline packs. Eventually the crust was entirely removed and the unhealed granulating areas were skin grafted.

General Therapy—Diet The patient was given a diet of 2,000 calories every day, of this, the daily protein comprised 40 Gm (6.3 Gm of N) the first 12 days, 80 Gm (12.9 Gm of N) the next six days, and 120 Gm (19 Gm of N) the last 12 days. Vitamin B was given in the form of Betalin tablets and brewers' yeast. Ample amounts of the other vitamins were also administered. Transfusions (500 cc whole blood) were given every third or fourth day (see chart at points marked T).

Fluids—The patient received 4,000 to 6,000 cc of fluids per day up to the tenth post-entrance day and during the eighteenth to thirtieth days, between the tenth and eighteenth

Submitted for publication January 26, 1939

days the amount was increased to 6,000 to 11,000 cc. As much as possible was given by mouth, but it was necessary to supplement it each day with subcutaneous saline and intravenous glucose. Continuous venoclysis was begun on the seventh postburn day and terminated on the sixteenth day. We believe that the high fluid intake and output was of great therapeutic value. It will be noted that during the peak of fluid intake and diuresis the blood N P N fell significantly (tenth to eighteenth day).

Drugs—Adrenal cortex extract was used in burns by Wilson, Rowley and Gray.¹ In experimental burns, it was used by Einhauser,² who reported a favorable effect on mortality. In this patient, it was used largely to increase urinary output because anuria is common to both adrenal insufficiency and severe burns. A dose of 5 cc * was given on the fifth and eighth days and 10 cc during the sixth and seventh days (intravenously). The administration was terminated because there was some doubt as to whether the drug was having any effect in increasing the urinary output which, indeed, was never very low.

Sulfanilamide was given by mouth largely because of the extensive local infection about the buttocks. A dose of 60 gr per day was given during the sixth to twelfth days, thereafter it was reduced to 30 gr per day up to the twenty-first day, when it was discontinued. Morphine, codeine, and aspirin were given as needed for pain and insomnia.

Laboratory Data (see also Chart 1)—The chemical methods used were all standard except for blood diastase which was determined by the procedure described by Somogyi.³ It should be noted that protein metabolism has been discussed and the data presented in terms of nitrogen intake and output.

Examination—The red blood count was 7,000,000 on entry (third postburn day). The count gradually dropped to 3,500,000 on the fourteenth postburn day and then varied from 3,500,000 to 4,500,000.

The patient became jaundiced on his seventh postburn day and had an icteric index of 80. At the same time the urine showed a strongly positive test for urobilin and a trace of bile (the latter for one day only). It is interesting to note that the red blood count dropped to 4,500,000 on this day, whereas, it was 7,000,000 three days previously. The icterus was probably not obstructive but either of hemolytic or hepatogenous origin.

The white blood count was 40,000 on entry and reached the high total of 82,000 on the twelfth day. After this, the count varied from 50,000 to 35,000 until the thirtieth day when it dropped to 30,000. The count was 20,000 on the forty-ninth day and 14,000 on the seventieth day. During the first 30 days, differential counts showed many immature cells. One particular smear, on January 12, 1938, showed juveniles, myelocytes, and promyelocytes. Some plasma cells were seen. At no time was there a palpable spleen or a generalized lymphadenopathy.

The nonprotein nitrogen of the blood (in mg per cent) ranged from 43 to 48 for first 11 days, then gradually dropped to 30 by the fifteenth day. At this time patient was receiving 11,000 cc of fluids daily. The protein intake was doubled at about this time and the fluids were gradually decreased to 4,000 cc per day, following this, the nonprotein nitrogen rose to 40 on the eighteenth day and stayed near this level until the twenty-fifth day, when it dropped to 30. Later it dropped to 19 (normal).

Serum protein was 4.9 Gm per cent at entry (third postburn day). However, the serum protein rose above the edema level in several days and stayed between five and six throughout the whole month. There was a reversal of the albumin-globulin ratio due to a progressive loss of the albumin fraction. There was no tendency to develop edema at any time. The blood diastase remained normal.

The blood cholesterol remained low for first 28 days, dropping as low as 87 mg per cent on the seventh day. This is compatible with a high basal metabolism. The high metabolism is consistent with the increased destruction of proteins as shown by the high output of nitrogen in the urine. The patient lost weight rapidly in spite of a high caloric,

* The adrenal cortical extract was generously supplied by the Upjohn Co.

high protein (120 Gm) diet The creatinine nitrogen (an index of the endogenous protein metabolism) was taken once and was found to be high (23 Gm per 24 hours) The basal metabolic rate was not taken

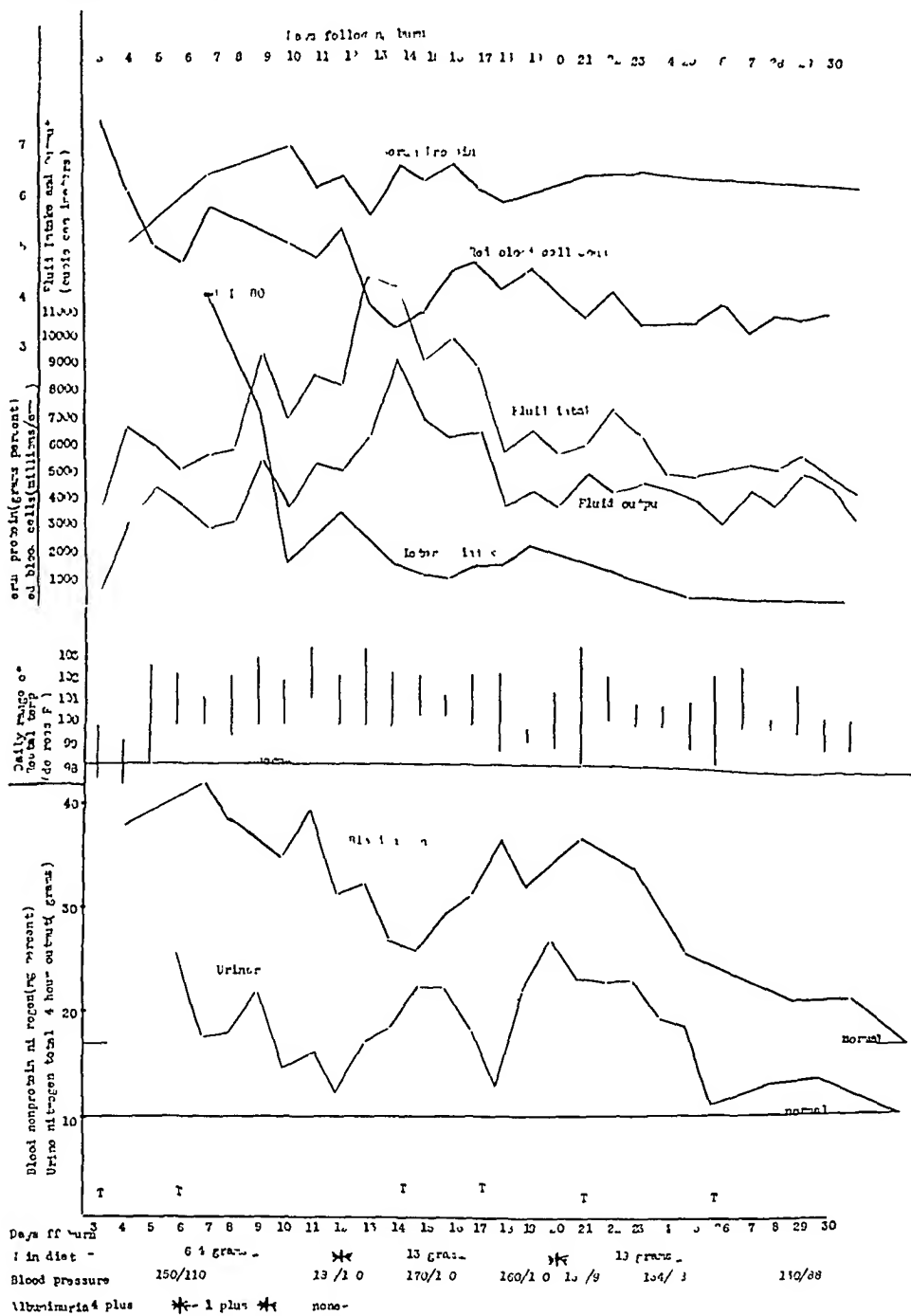


CHART 1—Chemical and metabolic data as described in the text Abb II = Icteric index T = Transfusions of 500 cc of whole blood NPN = Nonprotein nitrogen

Urine—Albuminuria was present (four plus) the first seven days, dropped to a one plus on the eighth to eleventh days, but thereafter was negative The urinary nitrogen was high for the first 25 days This is in keeping with a high basal metabolism, with destruction of tissues high in protein and with low blood cholesterol Urinary nitrogen was

30 Gm on the third day, dropped to 13 Gm on the eleventh day, rose to 25 Gm on the fifteenth day and stayed at this figure most of the time, until the twenty-third day. It then dropped gradually to 12 Gm by the twenty-sixth day, and later dropped to 10 Gm, which is about normal for such a diet. Specific gravity was at all times normal.

Urobilin was found in the urine during the first 12 days, was faintly positive the next two days and then remained negative (Schlessinger test). This urobilinuria may have been hemolytic or hepatogenous in origin, it is consistent with a high icteric index such as was present during the first 18 days. The Smith iodine test for urinary bile was faintly positive on the sixth day, but thereafter was negative. Although anuria was anticipated it did not occur. Fluid intake was kept high to combat anuria. Adrenal cortex hormone was also given for this purpose.

COMMENT—It will be noted first of all that there was an early concentration of red blood cells due, undoubtedly, to the large loss of plasma through the burned area. This effect has been described by Underhill,⁴ *et al*, Beard and Blalock,⁵ McIver,⁶ Harkins,⁷ and others. Of particular interest in this case, is the evidence of additional and tremendous loss of protein as shown by the high nitrogen excretion in the urine. This is often referred to as "toxic" destruction of protein, it has long been observed in typhoid fever and other severe infections and is mentioned by Einhauser² as occurring in burns. It also occurs in severe hyperthyroidism, the chemical findings in the present case, particularly the low blood cholesterol, suggested hyperthyroidism even though no basal metabolic rate was obtained. The nitrogen excretion was so high that it was impossible to bring the patient in nitrogen-balance even though a high caloric, high protein diet was ingested. During the first nine days, the negative nitrogen-balance added up to 120 Gm, during the next nine days, it fell to 80 Gm owing to an increase in the protein intake, during the next nine days, it fell further to 20 Gm with a further increase in the protein intake. Although this certainly suggests the importance of a high protein diet, the better balance in the last periods may also have been due to an improvement in the clinical condition of the patient. The total nitrogen deficit was, of course, much greater than the figures indicate because fecal nitrogen and loss of nitrogen through the burned areas were not included. In this patient, the feces were not collected but were probably not significantly large, the loss of plasma protein through the burned area on the other hand, though difficult to measure directly, was undoubtedly large. Although toxic destruction of protein is usually attributed to fever *per se* there was only moderate hyperpyrexia in this patient.

A second observation of interest, was the high nonprotein nitrogen of the blood, this, with hypertension and other clinical evidence of uremia, while they point to a derangement of the kidney, could scarcely be attributed to renal insufficiency in view of the large output of normal urine. Indeed, during the most acute days of "pseudo-uremia" the high point of urine output (8,000 cc) was reached. Could the uremic signs have been due to hepatic insufficiency? Were they manifestations of the "toxic" destruction of protein?

A third point of interest was the jaundice and urobilinuria during the first days of illness. Although this may have been a manifestation of hemolysis (fall of red blood count) the existence of hepatic insufficiency cannot be ex-

cluded Certainly, there was no hemoglobinuria, and, although the stools were not studied, no alteration in their pigment content was observed grossly While sulfanilamide was given the maximum dose was small (4 Gm per day), such manifestations have nevertheless been described as occurring after the ingestion of this drug In this case, however, the jaundice appeared almost simultaneously with the first dose of the drug and disappeared while it was still being given (see Chart 1)

CONCLUSIONS

Metabolic and chemical data are presented in the case of a severe burn, which indicate, among other findings First, a tremendous destruction of protein, as shown by the high urinary output of nitrogen, second, uremic manifestations without evidence of renal insufficiency, and third, a bile pigment disturbance, presumably hepatogenous or hemolytic in origin The importance of a high protein intake in the treatment of burns is emphasized, not only to replace loss of plasma protein *per se*, but also to cover the tremendous loss of nitrogen in the urine

REFERENCES

- ¹ Wilson, W C Rowley, G D, and Gray, N A Lancet 1, 1400, 1936
- ² Einhauser, M Klin Wchnschr, 17, 127, 1938
- ³ Somogyi, M Jour Bio Chem, 125, 399, 1938
- ⁴ Underhill, F P, Kapsinow, R, and Fisk, M E Amer Jour Physiol, 95, 302, 315, 325, 330, 334, 1930
- ⁵ Beard, J W, and Blalock, A Arch Surg, 22, 617, 1931
- ⁶ McIver, M A Amer Jour Surg, 97, 670, 1933
- ⁷ Harkins, H N Arch Surg, 31, 71, 1935

SODIUM MORRHUATE REACTIONS

REPORT OF TWO SEVERE REACTIONS DURING THE INJECTION TREATMENT OF VARICOSE VEINS

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THE SAFETY and effectiveness of the injection treatment of varicose veins has been definitely established during the past 12 years. A number of sclerosing solutions have been found to be fairly satisfactory but the search for an ideal one continues. Such an ideal solution should be one in which the constituents are pure and may be standardized. It should be painless, nontoxic, producing a prompt and firm thrombus, and not producing a slough when injected outside the vein.

The first note on the preparation of sodium morrhuate was by Rogers,¹ in 1919. In 1926, Cutting² gave the physical properties of the solution and described the technic of its preparation in more detail. Rogers³ stated, in 1930, that, in 1918, he had noted the sclerosing action of sodium morrhuate upon veins. But Kittel,⁴ in 1930, stated he had noted the effect of sodium morrhuate upon veins and had first suggested its possibilities as a sclerosing agent in the treatment of varicose veins.

From 1930 to 1933, numerous articles appeared extolling the effectiveness and safety of sodium morrhuate in the treatment of varicose veins. Levi,⁵ in 1930, stated that in 4,000 injections he had observed no general toxic symptoms. In 1932, Kilbourne, Dodson and Zeiler⁶ concluded that sodium morrhuate was not a toxic solution. Also in 1932, Tunick and Nach⁷ stated that in their experience sodium morrhuate was the closest approach to the ideal solution, and that they had observed no systemic or toxic symptoms from its use. F. L. Smith,⁸ in 1932, stated that sodium morrhuate was first used in this country at the Mayo Clinic in October, 1930. In an experience of 4,000 injections he had found that the solution produced no general systemic reactions and that it had become his solution of choice.

In 1933, Cooper⁹ stated that in 4,000 injections in 600 patients he had found sodium morrhuate to be nontoxic and that it met all the requirements for a safe and effective sclerosing agent. Also in 1933, Ochsner¹⁰ concluded that sodium morrhuate was not toxic and was the most efficient sclerosing agent.

In 1933, two reports appeared which were at variance with the generally reported opinion regarding sodium morrhuate. Haines¹¹ found there was a great variation in the composition and purity of various commercial samples

Submitted for publication February 15, 1939

of sodium morrhuate. Then, in November, 1933, Biegeleisen¹² reported his experiences with various sclerosing solutions. He concluded that sodium morrhuate was an unknown, relatively unstable mixture of sodium salts of unsaturated acids found in cod liver oil and that its potency diminished with age and was not uniform.

In 1934, Zimmerman¹³ reported the first serious allergic-like reaction to sodium morrhuate, listing four cases. In 1935, Praver and Becker¹⁴ reported cutaneous eruptions or nitritoid crises in seven out of 176 patients who had received 783 injections. Lewis,¹⁵ in 1936, reported a severe systemic reaction following the injection of sodium morrhuate. He stated his colleagues had had three similar cases. All four cases had had injections of sodium morrhuate at a previous interval of one year or more. In February, 1937, Dale¹⁶ reported a severe reaction with vascular collapse. His case reacted differently from previously described reactions in that there was no cessation in treatment prior to the reaction.

In August, 1937, Hatcher and Long¹⁷ reported a reaction to sodium morrhuate in which there was not only a severe general reaction but also a transient paralysis of one arm. Traub and Swarts¹⁸ in September, 1937, reported two cases, in detail, of anaphylactic reactions to sodium morrhuate. They mentioned they had had a third case and that Dr. A. Wilbur Duryee had seen three similar cases. In each of these cases there was a "rest period" of from four months to three years between courses of injections. In November, 1937, McCastor and McCastor¹⁹ reported two reactions, one occurring in a varicose vein injection and one from injection of sodium morrhuate into an hydrocele. Simmons,²⁰ in March, 1938, reported two general reactions from the use of sodium morrhuate in internal hemorrhoids. The reactions occurred on the second injection after an interval of one week.

Discussion—The mechanism of the reactions is still obscure. It was suggested by Zimmerman¹³ that the reactions may result from liver proteins in the sodium morrhuate or from the saponified fatty acids themselves. Praver and Becker¹⁴ analyzed the protein content of sodium morrhuate samples and concluded that "the protein content is not sufficient in itself to produce sensitization but the sodium morrhuate may act as a haptene and sensitize susceptible individuals." However, Lewis¹⁵ concluded that the reactions were due to some protein liver radical in the sodium morrhuate solution to which certain individuals become sensitized and in whom later injections with the same solution caused foreign protein reactions. Dale¹⁶ felt that the reactions were not anaphylactic, due to some liver protein as suggested by Lewis, but rather a specific reaction due to an idiosyncrasy to the sodium morrhuate.

Simmons²⁰ stated that another theory which has been offered is that hemolysis may occur, the contact of the patient's blood with the solution resulting in the liberation of protein substances which are responsible for the reaction.

A study of the reported cases shows that most of the very severe gen-

eralized reactions occurred on the first or second injection following a "rest period" of from several months to three years after the first course of injections. Also many of the cases had slight reactions in earlier injections, which were only noted when viewed in retrospect and the severe reaction could have been prevented by avoiding further injections of sodium morrhuate. The reported reactions occurred from the preparations of various pharmaceutical houses, so it seems reasonable to rule out any impurity or contamination arising from the manufacture of the solutions.

In the Varicose Vein Clinic of the Stanford University Medical School, more than 4,000 injections of sodium morrhuate have been given and two severe reactions have been noted. Except for these reactions, we have found sodium morrhuate to be a safe and effective solution for the treatment of varicose veins. There have been but four sloughs from the use of the solution, and no pulmonary complications.

Following are the case reports of two severe reactions following the injection of 5 per cent sodium morrhuate in the treatment of varicose veins.

Case 1—C. E., male, age 63, was first seen, June 3, 1933, for a varicose ulcer of the left leg and severe varicosities of both legs. A high ligation of both saphenous veins was performed, and this was followed by several injections of 20 per cent sodium chloride. He returned to the Clinic, June 11, 1934, 11 months later, with a varicose ulcer of the right calf. He received seven injections of 2 cc of 5 per cent sodium morrhuate at intervals of from one to two weeks. Before the treatments were completed he again disappeared for 11 months. He returned in September, 1935, with a small ulcer on the right leg. He received two injections of 2 cc of sodium morrhuate each on two occasions, and then failed to report to the Clinic for eight months. On July 2, 1936, he returned for a continuation of his treatment and was given 2 cc of sodium morrhuate with no reaction. One week later he was again given two injections of 2 cc of sodium morrhuate.

Immediately after the second injection the patient broke out in a cold sweat. He felt ill and stated he had pain in the pit of his stomach. A short time later he began having tingling and burning of the palms of his hands. An urticarial rash appeared on the volar surface of his forearms. Blood pressure 160/100. Pulse 100. Gradually, within 15 minutes, the symptoms subsided. Epinephrine was not administered because by the time the rash appeared he was beginning to feel better. The patient was able to go home after resting an hour.

He was seen one week later. The ulcer had healed. There were no general symptoms. Two weeks after the reaction, he returned and was seen by another physician who did not read the patient's history carefully and thought that the reaction described referred to a local reaction which had subsided, so he injected 2 cc of sodium morrhuate. Five minutes following the injection the patient coughed, wheezed and drooled at the mouth. His pulse became very weak and extremely rapid. He rapidly became cyanotic and then lost consciousness. The blood pressure fell to 50/40. His face and tongue became swollen. The respirations were extremely stertorous and then spontaneous breathing ceased for several minutes. The air passages were opened by pulling the tongue forward with a clamp and artificial respiration was started. Oxygen was administered through a nasal catheter and he was given 1 cc of 1:1,000 epinephrine and $7\frac{1}{2}$ gr of caffeine sodium benzoate hypodermically. After five minutes, spontaneous respiration was resumed and it was possible to stop the artificial respiration. Within 20 minutes the color had improved, his blood pressure had risen to 80/60 and pulse slowed to 100. He was given an additional 0.5 cc of epinephrine. His condition continued to improve and he regained consciousness in about a half hour. Fifteen minutes after the onset of the reaction, he

began to cough up pink-tinged frothy fluid and this continued in decreasing amounts for one hour. After two hours of rest in the Clinic it was possible to move him into the hospital where he was kept for two days.

On admission to the ward his temperature was 38° C, pulse 120, blood pressure 120/60. Within a short time, the blood pressure dropped to 80/40 and he again became cyanotic. He was given ephedrine gr ¼ and the 7½ gr of caffeine sodium benzoate was repeated. One hour later, the pressure was up to 110/80 and his general condition was improving. R B C 4,790,000, 90 per cent hemoglobin, W B C 17,000, 82 per cent polymorphonuclears, 17 per cent lymphocytes, 1 per cent monocytes. Blood Wassermann negative. Urine examination negative.

He showed no further signs of shock and was dismissed on the second day. Examinations in the Clinic later failed to show any residual signs or symptoms from the reaction.

Case 2 —H M, male, age 73, was first seen in the Varicose Vein Clinic, November 23, 1931. He had had severe varicose veins for many years. He had had stripping operations of both legs in 1903, and again in 1913. On admission he showed marked varicosities of both legs. During January and February, 1932, he had high ligation of both saphenous veins with injection of the distal ends with 20 per cent sodium chloride. He received two injections of 2 cc each of sodium morrhuate on three occasions. He returned to the Clinic 18 months later with a recurrence of some of the varicosities. He was treated with a series of injections of 20 per cent sodium chloride. Nine months later, he was treated with sodium morrhuate, making 13 visits at weekly intervals and receiving one to two injections of 2 cc each on each visit. He had no reactions from the injections. Then he was not seen again in the Clinic for three years. He returned, October 11, 1937, with bilateral recurrences. He was injected with 0.5 cc of sodium morrhuate and there was no reaction. On October 15, 1937, he was injected with 2 cc of sodium morrhuate. Some generalized itching of the skin was noted but he did not mention it before the next injection. On October 21, he received another injection of 2 cc. Again, there was pruritis lasting about three hours. Again, he did not mention the itching before the next injection. On October 28, he again had the itching, this time with the development of wheals lasting about three hours. On November 4, he again made no mention of any of the previous reactions, later stating that he did not think the itching amounted to anything. He was given two injections of 2 cc each of 5 per cent sodium morrhuate. He had no immediate reaction. While leaving the Clinic, about ten minutes after receiving the injections, he felt chilly and began to itch all over. He thought he would try to "walk it off" but the symptoms continued to increase in severity. Within 15 minutes, he felt as though his face were swelling, especially the upper lip. The upper lip was puffed up and felt stiff, his tongue became swollen and a half hour after leaving the Clinic he fainted on the street and believes he was unconscious for several minutes. He was taken into a house, his clothing loosened and he gradually improved so that he was able to continue on to his home after another half hour. For the following four days he stated that he had no appetite. Twenty per cent sodium chloride was used for subsequent injections and a good thrombosis was obtained.

CONCLUSIONS

Two additional cases are reported of severe anaphylactoid reactions following the injection of 5 per cent sodium morrhuate.

The two reactions reported here are the only serious complications we have noted in more than 4,000 injections of 5 per cent sodium morrhuate.

Most of the recorded severe reactions have occurred on the first or second injection following a "rest period" of from several months to three years after a course of injections of sodium morrhuate.

There are usually signs and symptoms of increasing sensitivity with succeeding injections, and severe reactions may be prevented by stopping the use of the solution. The patient should be carefully questioned before each injection regarding any reaction to previous injections.

Small doses of not more than 0.5 cc should be used for several injections on beginning the second and subsequent courses of injections when using sodium morrhuate.

The cause of these late reactions is still obscure.

REFERENCES

- ¹ Rogers, L. The Preparation of Sodium Morrhuate. *Brit Med Jour*, 2, 426, September, 1919.
- ² Cutting, R. A. The Preparation of Sodium Morrhuate. *Jour Lab and Clin Med*, 11, 842, June, 1926.
- ³ Rogers, L. Intravenous Sclerosing Solutions. *Brit Med Jour*, 120, July 19, 1930.
- ⁴ Higgins, T. T., and Kittel, P. B. The Use of Sodium Morrhuate as a Sclerosing Agent in the Treatment of Varicose Veins. *Lancet*, 1, 68, January 11, 1930.
- ⁵ Levi, D. The Relative Value of Various Solutions for Sclerosis of Varicose Veins. *Lancet*, 2, 16, July 5, 1930.
- ⁶ Kilbourne, N. J., Dodson, W., and Zeiler, A. H. Researches in Toxicity, Slough Producing Properties and Bactericidal Actions as Related to Phlebitis and Embolism. *Surg, Gynec and Obstet*, 54, 640-649, 1932.
- ⁷ Tunick, I. S., and Nach, R. Sodium Morrhuate as a Sclerosing Agent in the Treatment of Varicose Veins. *ANNALS OF SURGERY*, 95, 734-737, May, 1932.
- ⁸ Smith, F. L. Sodium Morrhuate for Treatment of Varicose Veins. *J A M A*, 99, 2008-2010, December 10, 1932.
- ⁹ Cooper, W. M. The Use of Sodium Morrhuate in Injection Treatment of Varicose Veins. *Amer Jour Surg*, 21, 408-410, September, 1933.
- ¹⁰ Ochsner, A. The Relative Value of Sclerosing Agents in the Treatment of Varicose Veins. *Southern Surg*, 2, 217-224, 1933.
- ¹¹ Haines, R. Sodium Morrhuate Variation in Commercial Samples. *Lancet*, 1, 748-749, 1933.
- ¹² Biegeleisen, H. The Evaluation of Sodium Morrhuate Therapy in the Treatment of Varicose Veins. *Surg, Gynec and Obstet*, 57, 696-700, November, 1933.
- ¹³ Zimmerman, L. M. Allergic-Like Reactions from Sodium Morrhuate. *J A M A*, 102, 1216-1217, April 14, 1934.
- ¹⁴ Prayer, L. L., and Becker, S. W. Sensitization Phenomena Following the Use of Sodium Morrhuate for the Chemical Obliteration of Varicose Veins. *J A M A*, 104, No 12, 997, March 23, 1935.
- ¹⁵ Lewis, K. M. Anaphylaxis Due to Sodium Morrhuate. *J A M A*, 107, 1298, October 17, 1936.
- ¹⁶ Dale, M. L. Reaction Due to Injection of Sodium Morrhuate. *J A M A*, 108, No 9, 718, February 27, 1937.
- ¹⁷ Hatcher, M. B., and Long, H. W. Unfavorable Reactions from Sodium Morrhuate. *Jour M A Georgia*, 26, 427-428, August, 1937.
- ¹⁸ Traub, E. F., and Swarts, W. B. Collapse Complicating Varicose Vein Injection of Sodium Morrhuate. *New York State Jour Med*, 37, 1506-1508, September 1, 1937.
- ¹⁹ McCastor, J. T., and McCastor, M. C. Reaction to Sodium Morrhuate Injections for Varicose Veins and Hydrocele. *J A M A*, 109, 1799-1800, November 27, 1937.
- ²⁰ Simmons, N. J. Anaphylaxis to Sodium Morrhuate Following Injection Treatment of Internal Hemorrhoids. *New England Jour Med*, 218, No 12, 527-529, March 24, 1938.

MASSIVE DOSES OF LUGOL'S SOLUTION IN ACUTE, SECONDARY PAROTITIS

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AND

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IN 1929, one of the authors (D J L) began the treatment of acute, secondary parotitis with massive doses of Lugol's solution. In this rare disease, which has a mortality rate of 30 per cent, this treatment has proved most gratifying. We¹ reported the results of our first ten cases in May, 1935. There were no deaths in this series. With the cooperation of other members of the profession, we have, since then, accumulated 13 other cases, which form the subject of the present communication.

In this article, we shall, intentionally, omit any reference to diagnosis and etiology^{2 3} of acute, secondary parotitis. The first is self-evident, and the latter, a controversial subject well discussed elsewhere. We shall direct our attention chiefly to the treatment of this disease with massive doses of Lugol's solution, stressing our results as compared with other forms of treatment.

Symptomatic treatment of acute secondary parotitis over a period of 50 years has had little effect on the mortality rate. The first advancement was made by Rankin and Palmer,⁴ who, in 1930, introduced the "Radium Pack Treatment." This treatment could be effectively applied, and properly controlled only by a competent radiologist, and available only to those of means. Thus the radiologist soon turned to roentgenotherapy as a substitute. In this field, Robinson and Spencer⁵ were pioneers. Roentgenotherapy appears to be as effective as radium, and to-day is extensively employed in the treatment of this disease. Its administration has reduced the mortality rate to about 20 per cent.

The treatment of parotitis by dilating Stenson's duct, predicated upon the underlying pathology being a duct obstruction, requires some elucidation. Hobbs and Sneerson^{6 7} have written several comprehensive articles on the subject, and presented sialograms as evidence of their contention. In one of their more recent articles, they advocate dilatation of the duct only in cases of ascending infections and state that dilatation is never indicated in hematogenous infections. In our cases, we were unable to make such a differential diagnosis. We believe that dilating Stenson's duct in any case of acute, fulminating parotitis requires the utmost caution. In cases of frank obstruction, which as a rule are uninfected, dilatation is the treatment, here,

neither roentgenotherapy nor Lugol's solution is of value. They report a mortality rate of 20 per cent.

The therapeutics of Lugol's in parotitis is not well understood. It may be due to the parotid sensitivity to iodine,⁸ and the metabolic changes that occur in the gland during its elimination, or by the direct action of the high concentration of the iodine ion on the bacteria. The glands are indeed very prompt and active in the elimination of iodine. As the iodine is eliminated by the parotids, it is promptly reabsorbed by the intestinal tract, completing cycle after cycle through the glands, until final elimination by the kidneys, which requires from 40 hours to several days. We are inclined to believe that the beneficial effect must lie in this constant concentrated flow of iodine through the parotids, be it antiseptic or metabolic in character.

In parotitis, Lugol's solution is administered orally, by vein and hypodermoclysis. Our average daily dose is 160 minims, 20 minims every three hours day and night. In fulminating cases, an additional one or two drachms of Lugol's solution is given intravenously or subcutaneously, in saline or glucose, one drachm to the 1,000 cc. We continue this daily dosage until the inflamed gland shows definite signs of improvement, then the dose may be gradually decreased, and discontinued when the active process has subsided. We never incise the gland if an abscess forms, but aspirate the pus daily through a large caliber needle. These abscesses, when they occur, are usually multiple and discrete, due to pressure necrosis, thus adequate drainage is seldom accomplished by incision. Incision invites mixed infection which adds to the seriousness of the disease.

ILLUSTRATIVE CASE REPORTS

Case 3—Miss M. M., age 13, on November 3, 1935, had a ruptured appendix with general peritonitis. She recovered from the acute process in 12 days. On November 27, pain again developed in the abdomen. The appendix was then removed. There were many long "guy-rope" adhesions, and a straw-colored serum in the general peritoneal cavity as evidence of recent general peritonitis. On November 29, a right parotitis developed which became quite severe the following day, temperature 103° F, pulse 120. Lugol's solution, minims 20, was given every three hours, and minims 60 in 1,000 cc of saline daily by hypodermoclysis. By December 1, there were definite signs of improvement and the Lugol's solution was gradually diminished. The swelling and other signs completely disappeared by December 5. She was discharged the following day. A *Staphylococcus aureus* was cultured from Stenson's duct. Six hundred ten minims was the total amount of Lugol's administered.

Case 4—Mrs. R. C., age 47, suffered with two large cystic ovaries. Her abdomen was the size of a full term pregnancy. On October 8, 1938, a bilateral oophorectomy was performed, each specimen was about 20 cm in diameter. There were broad vascular bands of adhesions firmly attaching the ovaries to the surrounding structures. The left ovary was so firmly adherent in the pelvis that the fibrous capsule was left *in situ*. Surgery in this case was very extensive. On October 10, a double parotitis developed with a temperature of 105° F, pulse 136, marked cyanosis and shock. She was not expected to recover. Lugol's solution, minims 20, was given every three hours orally, in addition minims 60 in 1,000 cc glucose intravenously and minims 60 in saline interstitially, daily.

Lugol's solution was discontinued. In Case 7, rupture of the abscess may have been avoided by earlier aspirations. Spinal anesthesia was given in every operative case except Case 8, which had ether. Nausea from the Lugol's was overcome by decreasing the oral and increasing the parenteral administration. The water balance was carefully maintained in all cases. There were no deaths in either series except Case 11, which developed bronchopneumonia after recovery from the parotitis and died four days later. This case responded well in spite of a concomitant diabetes. Case 4 was not expected to recover, there was marked cyanosis, severe shock, temperature 105°F , pulse 136, at the onset. Within three days, on massive doses of Lugol's and oxygen, the improvement was striking (Table I).

SUMMARY AND CONCLUSION

(1) Thirteen cases of acute secondary parotitis, treated with massive doses of Lugol's solution, are herewith reported, making a total of 23 cases treated by us to date.

(2) There were no deaths. One case which had recovered from the parotitis, developed bronchopneumonia, and died four days later.

(3) In most cases, pus was easily expressible from Stinson's duct, and the organism was recovered in every case that was cultured.

(4) The most effective method of treating secondary parotitis is with massive doses of Lugol's solution.

We wish to express our appreciation to Drs. James Blain, Louis Stern, Lionel Braun and Adolph Spiro for permitting us to observe their cases, their excellent cooperation has made this publication possible.

REFERENCES

- ¹ Leithauser, D. J., and Cantor, M. O. Lugol's Solution in Acute Secondary Parotitis. *ANNALS OF SURGERY*, 101, 1171-1174, May, 1935.
- ² Talbot, H. S. Acute Suppurative Parotitis, Its Etiology, Pathogenesis, and Treatment. *Amer Jour Surg*, 25, 267, August, 1934.
- ³ Blair, V. P., and Padgett, E. C. Pyogenic Infections of Parotid Gland and Ducts. *Arch Surg*, 7, 1-36, July, 1923.
- ⁴ Rankin, F. W., and Palmer, B. M. Postoperative Parotitis, Treatment without and with Radium. *ANNALS OF SURGERY*, 92, 1007, December, 1930.
- ⁵ Robinson, M. J., and Spencer, J. Roentgen Therapy of Acute Postoperative Parotitis. *New England Jour Med*, 215, 150, July 23, 1936.
- ⁶ Hobbs, W. H., Sneerson, H., and Faust, C. L. Acute and Chronic Infections of the Parotid Gland. *Surg, Gynec and Obstet*, 54, 555, March, 1932.
- ⁷ Hobbs, W. H., and Sneerson, H. Infections of Parotid Gland, Further Studies on Etiology and Treatment, Sialograms of Normal and Abnormal Gland, Including Tumors. *Amer Jour Surg*, 32, 258-271, March, 1936.
- ⁸ Carter, W. *Liverpool Medico-Chir Jour*, July, 1906, quoted by Sajous, C. E. deM. *Sajous Analytic Cyclopedia of Practical Medicine*, 6, 29, 1921.

BRIEF COMMUNICATIONS AND CASE REPORTS

RECONSTRUCTION OF A HAND AND FOUR FINGERS BY TRANSPLANTATION OF THE MIDDLE PART OF THE FOOT AND FOUR TOES

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MONACO

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IN 1917, the author¹ published the preliminary report of this case and the immediate result. The patient was subsequently lost sight of until Ranschburg recorded the ultimate result in a neurologic review.

Case Report—M J, a Hungarian soldier, had had his right hand mutilated by a hand grenade in 1917, so that only the thumb, which was rigid and deeply scarred, and the root of the hand with a very small portion of the metacarpus remained.

Operative Procedure—All scar tissue was excised from the injured hand. The remaining metacarpus were exposed and the extensor tendons liberated. A curved incision was then made over the dorsum of the right foot which penetrated to the sheaths of the tendons which were sectioned one inch proximal to the line of incision (Fig 1). The tissues were then raised close to the base of the metatarsus. The metatarsus were resected one inch distal to the line of the skin incision. The sections were not made in the same plane, not only to protect the deep sutures, but more particularly to establish a maximum of contact between the tissues of the hand and those of the foot without the lines of contact between nonsimilar tissues being contiguous.

Holding the four toes and the sectioned metatarsus thus mobilized, in the left hand, they were extended plantarwards as far as possible, so that distal segments of the metatarsus and those from the remainder of the foot could be raised and freed some inches from the tissues of the sole of the foot. The portion to be transplanted, which was only pedicled on the side of the sole of the foot, was quite mobile. The hand was now placed in contact with the foot. First, the periosteum of the metatarsus was sutured to that of the metacarpus with catgut. This was difficult to accomplish and, at certain points, the periosteum could be coapted only with the support of the fascia.

The extensor tendons were sutured together with fine silk and a few sutures of fine catgut were employed to unite the sheaths of the tendons with the adjacent tissues. The fascia was sutured with catgut, and bronze-aluminum sutures were placed in the skin.

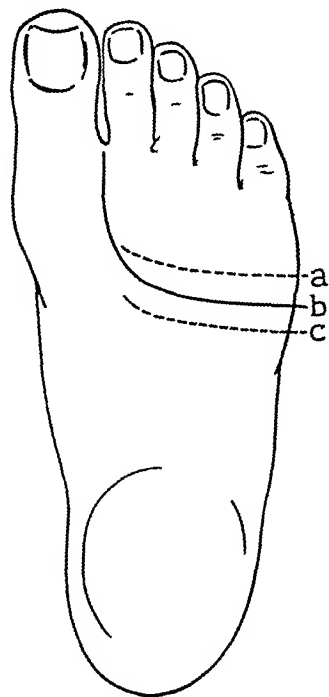


FIG 1—Line drawing of the right foot showing (a) the level of section of the metatarsus, (b) the line of the skin incision, and (c) the level of division of the tendons.

It was considered a most important procedure to coapt the ends of corresponding vessels by suturing adjacent tissues about their juncture, in the hope of predisposing to, and facilitating, the formation of collaterals.

A plaster encasement, immobilizing the hand, arm, foot and leg, was applied, leaving the toes exposed. The patient was placed in bed and was well supported on every side.

Subsequent Course—During the first postoperative night, the patient fell out of bed



FIG 2—Photograph (20 years postoperative) showing the ultimate result viewed from the dorsal aspect

and tore out several of the skin sutures, the condition of the deep sutures could not be determined. Notwithstanding this accident, the wound healed quickly and well, partially by granulation.

Four weeks after operation, half the pedicle was cut off close to the fourth and fifth metatarsus, and in the wound thus formed, the tendons of the portion to be transplanted were sutured together separately, the sheath of the tendons and of the tissues to those

of the volar wound of the hand (fourth and fifth fingers) Several skin sutures of silver were introduced

Five days later, one month after the primary operation, the remainder of the pedicle was severed, and the tendons of the second and third fingers were sutured to those of the corresponding toes The skin wound was closed The secondary wound in the foot was treated in the following manner In order to obtain a good sole for the remainder of the foot, a section of the tissues of the sole was made as far distal as possible, so that the flap of the sole not only covered the entire plantar surface, but could also be sutured over the dorsum of the foot This procedure, undoubtedly, endangered the viability of the newly transplanted hand, as there remained only a small portion of skin for the hand with which to make an adequate covering for the muscles, nerves and vessels

The cicatrization had penetrated very deeply, but precautions had been taken that the point of junction of the tendons should not lie directly underneath, nor in contact with, the area of cicatrization in the skin, in order to prevent subsequent immobilization of the tendons

Final Result—The hand was perfectly capable of holding different objects Figure 2 shows the general appearance of the transplanted toes 20 years after operation The remaining big toe of the resected foot was in good condition, and the function of walking was in no way impeded The foot had retained its four points of support, only the point at the head of the fifth metatarsal had been replaced by one closer to the heel

PRACTICAL EFFECTS OF THE OPERATION AND THEIR NEUROLOGIC EXPLANATION

The Question of Spontaneous Union of Dislocated Nerves

PROFESSOR RANSCHBURG

The above reported case, which might well be captioned "The Man with the Foot-Hand," had had the stump of his right hand, with only the thumb left, repaired by means of a transplant of four toes and their corresponding metatarsus from his right foot This is certainly Doctor Esser's masterpiece of plastic or structive surgery I have had the opportunity of examining the patient several times since the operation, at the Neurologic Department of the Hospital of Budapest

The intention of the surgeon was to create a new hand by quite an original procedure, completing the misshapen and useless stump by a practical, usable instrument which was not only esthetically excellent, but which would also act as a practical motor

Neither before, nor for weeks after the operation was there any real voluntary motor-like activity of the "toe-fingers" Nevertheless, by the help of the thumb, through adduction, flexion and apposition to the toes, his hand has become quite a useful instrument for grasping, holding and drawing, only the mechanism lacked any information of a sensitive nature, *i e*, touch, pain, temperature, localization on the skin and orientation of the movements and position, if not assisted by the help of vision or the sound left hand

The patient was discharged from the hospital and ordered to return to the Follow-Up Clinic once a year for examination Meanwhile, Doctor Esser having left Budapest a few months after the operation, I had the opportunity

of repeatedly examining this most interesting case. He was very proud of his ability to use his right hand in disrobing and especially in lacing his shoes and unrolling his foot wrappings. He related and demonstrated how he had helped at the harvest in the usual way and generally performed most home and field labors with his "foot-hand" without any difficulty.

A most precise examination showed this eupraxia as being conditioned partly by motor-like, partly by sensitive support. From the motor-like side, there was to be found, besides the perfect use of the thumb in leaning and pressing it tightly against the "toe-fingers," an undoubtedly effective, although purely mechanical flexion of the "toe-fingers." This had been rendered possible by the help of the suture of the tendons, without the help of the short lumbricales and interossei, all of which were, of course, lacking, and also by active adduction of the "toe-fingers," the second on to the third, and the fourth on to the fifth, effective even against resistance, by means of the long extensors of the fingers. Thus, the acquired mobility could not be judged as an effect of a successful suture of the nerves, because the nerves of the long muscles had not been injured, but as a purely mechanical consequence of the perfectly successful orthopedic-surgical intervention.

Of course, this success would have been incomparably less, if the spontaneous juncture of the smashed, degenerated central stumps of the sensitive nerves of both sides of the hand, to the peripheral stumps of the foot, had not been so meticulously accomplished. The complete regeneration was due to the perfect circulation in the transplant.

The epicritical sensitiveness of touch, examined by stroking with a fine paint brush, was present on almost the whole volar and dorsal surfaces of the transplanted "foot-hand." Even a certain primitive localization of touch, generally found in the first stage of the recovery after nerve suture, was present, *i e*, each stimulation of the plantovolar skin of one of the toes was correctly signalized, also topically, whereas, dorsal touching of any toe had the coarser effect of being localized more proximally upon the surface of the skin of the corresponding "metatarso-metacarpal" region.

The sensibility to pain was obvious everywhere, and pin-pricks were localized about as correctly, or with the same errors, as those of the touch with the pencil, *i e*, they were, in the main, correct. Two simultaneous touches, as well as pin-pricks, were judged correctly as often as falsely, *i e*, 50 per cent of them, whereas, the touching of the normal sole of the left foot resulted in 75 per cent correct judgments from a distance of 4.5 Mm. of the point of the esthesiometer. Dorsally, the space amounted to 6 to 7 Mm. stereognosis on, beneath, and between the "toe-fingers," and examined by ring, knife, brush, *etc*, was stated as zero, whereas, with the toes of the unoperated left foot, it was satisfyingly correct and prompt.

The most striking phenomenon resulted from the examination of the sensibility to temperature. Stimulations by means of test-glasses filled with hot water or with pieces of ice gave correct reactions in 80 per cent of the tests, within three to five seconds. Even when repeatedly examined, the

unoperated left foot amounted to four to five times as many false reactions as the artificial "foot-hand." The explanation of this striking result may be found in the patient's habit of having wrappings around his feet, thus his left foot had been protected since childhood against all changes of temperature, whereas, the right "foot-hand" had been continuously exposed to such weather influences since the operation. Moreover, having been employed as a real hand in the judging of temperature, the "foot-hand" was necessarily put, since the restoration of the nerve conductions, into continual practice.

In a word, the "foot-hand" fulfilled all the ordinary functions of a normal hand, while walking on the remaining part of the right foot was in no way impeded.

REFERENCE

- ¹ Esser, J. F. S. Operativer Ersatz der Mittelhand nebst 4 Fingern. *Brunns' Beitr. z. Klin. Chir.*, 108, Zweites Heft, 244-248, 1917-1918.

SUTURE OF STAB WOUND OF INFERIOR VENA CAVA

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THE INDICATIONS for operation upon the inferior vena cava are rare. Barnes¹ reports a severe traumatic laceration which necessitated ligation, with recovery. In Sheppe's¹⁰ case, exploration of a gunshot wound of the abdomen revealed a bullet embedded in the anterior wall of the inferior vena cava above the bifurcation. Just as removal was to be attempted, it disappeared. The perforation was successfully closed by suture. The patient died five days later of peritonitis, and the bullet was found in the right ventricle. Wurzel¹³ reports a gunshot wound of the inferior vena cava closed by suture, with recovery. Conduct⁷ reports a case of scissors-perforation of the inferior vena cava, also closed by suture with recovery. The most common injury to the inferior vena cava is a tear or laceration occurring during the course of a right nephrectomy. Many such cases have been reported in the literature.^{2, 3, 7, 8, 12} Cole² reports a laceration occurring during the removal of an adherent retroperitoneal tumor, which was sutured with recovery. Pfaff⁹ reports a similar case in which ligation was performed. If the tear in the vena cava is below the level of the renal veins, it may be ligated with comparative safety. Ligation has also been performed for pelvic sepsis and thrombophlebitis. Wakefield and Mayo¹¹ report 19 such cases collected from the literature, with four deaths. Walters and Priestly¹² review the surgery of the inferior vena cava, and report four cases of their own in which the inferior vena cava was opened in the course of a right nephrectomy. In two of their cases, it was opened accidentally, and in two others it was opened intentionally in order to remove a papillary neoplasm.

extension of a hypernephroma protruding from the renal vein. In our case the laceration of the inferior vena cava was the result of a stab wound.

Case Report—The patient, Negro, male, age 41, was admitted to the Receiving Hospital, with lacerations of the chin and arms, and a stab wound in the right anterior axillary line in the eighth intercostal space. He thought these wounds had been inflicted with a pocket knife. *Examination* showed a moderately well nourished and well developed man. The abdomen was rigid. The direction of the wound in the right side

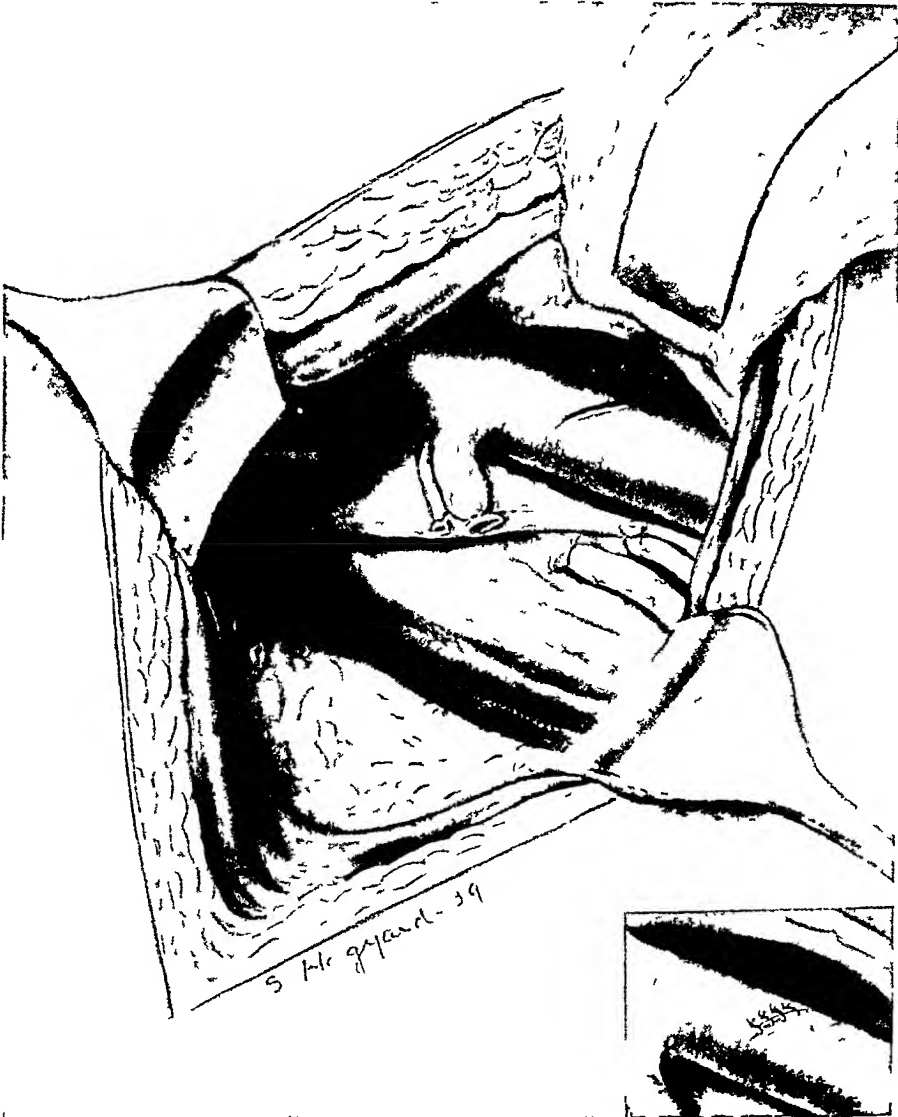


FIG 1—The laceration of the anterior surface of the inferior vena cava is shown in the depth of the wound. The kidney has been removed, and the renal artery vein, ureter and an accessory ureter have been ligated.

appeared to be downward, and as there was a strong possibility that it had penetrated into the abdominal cavity, it was decided to perform an exploratory celiotomy.

Operation—A right subcostal incision was made, and it was seen that the knife had grazed the anterior lateral border of the liver, and passing laterally and posteriorly to the duodenum and hepatic flexure of the colon, had penetrated the posterior parietal peritoneum overlying the upper pole of the right kidney. There was an enormous retroperitoneal hematoma. The rent in the peritoneum was enlarged, and the upper

pole of the right kidney presented. There was a large jagged hole in the kidney which was bleeding profusely. There was also blood coming from about the kidney. Two or three sutures were placed in the kidney in an ineffectual effort to stop the bleeding. As exposure was unsatisfactory, the hole in the posterior peritoneum was closed, and the subcostal incision closed. The patient was then placed on his left side, a transfusion was started, and a right kidney incision was made. A large pool of dark blood was immediately encountered, the kidney being in the center of it. The pedicle was clamped and severed, and several large laparotomy pads were inserted into the depth of the wound in an effort to control the bleeding, and the ureter and vessels were then ligated separately. An accessory ureter was likewise ligated. By this time the pads were saturated with blood. As they were carefully removed, there was a gush of blood from the depth of the wound. This area was compressed between the thumb and forefinger, and as a better exposure was obtained, we discovered the bleeding was coming from a



FIG 2

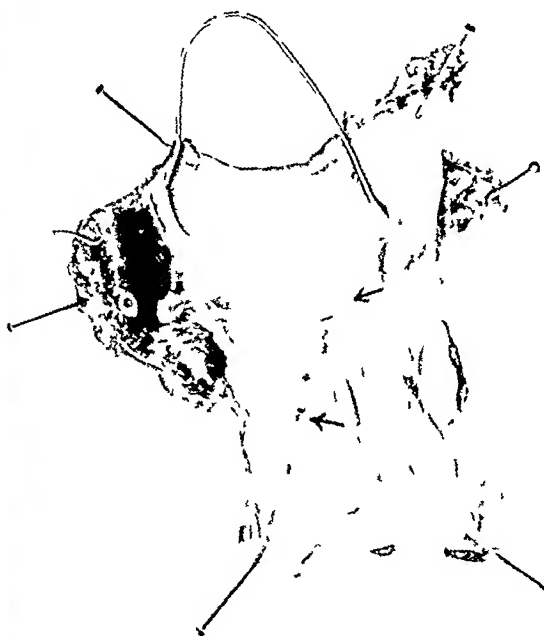


FIG 3

FIG 2—The patient four months after operation. The arrow points to the scar of the stab wound. FIG 3—Gross specimen of the inferior vena cava. The vein has been incised posteriorly so that the anterior wall of the interior surface is visible. The wire probe is seen protruding through the stump of the left renal vein while the other end is inserted into the stump of the ligated right renal vein. The arrows point to either end of the scar on the anterior surface of the vena cava. There is firm healing of the laceration without apparent weakening of the wall of the vena cava. There is a little puckering noticeable about the scar and the silk sutures are visible beneath the intima.

laceration about three-quarters of an inch in length on the anterior wall of the inferior vena cava. This was rapidly closed with five interrupted sutures of fine silk (Fig 1). Some fat was placed over it and the wound closed. The lacerations of the face and arms were sutured, and the patient was returned to the ward in fair condition.

Subsequent Course—His convalescence, except for a moderate wound infection with some separation which required resuture, was uneventful. At no time was there evidence of obstruction of the vena cava. He left the hospital on the twenty-sixth day (Fig 2).

Four months after the operation, he presented himself for treatment for a chronic pulmonary condition which antedated his accident. There was no evidence of obstruction of the vena cava.

The patient was readmitted to the hospital several months after this stab wound had been sutured, suffering from actinomycosis of the right lung. He died six months later. At autopsy, the gross specimen of the inferior vena cava, which contained the site of the sutured stab wound, was removed (Fig 3).

BIBLIOGRAPHY

- ¹ Barnes, W P Traumatic Laceration of the Inferior Vena Cava, with Recovery, Case Report Virginia Med Monthly, 65, 285-287, May, 1938
- ² Cabot, A T Two Cases of Injury of the Vena Cava During the Removal of Pyelonephrotic Kidneys Boston Med and Surg Jour, 127, 578-580, October 24, 1912
- ³ Clute, A L Injury to the Vena Cava During Nephrectomy Report of Four Cases Jour Urol, 13, 43-49, January, 1925
- ⁴ Cole, H P Laceration of the Inferior Vena Cava Repaired by Suture Recovery ANNAIS OF SURGERY, 66, 43, July, 1917
- ⁵ Condict, W L Perforated Gunshot and Stab Wounds of the Abdomen Treated at the Gouverneur Hospital of New York ANNALS OF SURGERY, 80, 51-55, July, 1924
- ⁶ Costa, G Wounds of the Inferior Vena Cava Arch Ital di Chir, 4, 339-388, November, 1921, Abstr J A M A, 78, 620, February 25, 1922
- ⁷ Nissen, R Suture of the Inferior Vena Cava Injured During Nephrectomy Deutsch Ztschr f Chir, 229, 142-143, October, 1930
- ⁸ Nora, G A propos de deux cas de plaies de la veine cava inferieure Jour d'urol med et chir, 28, 306-317, October, 1929
- ⁹ Pfaff, O G Ligation of the Inferior Vena Cava Am Jour Obst and Gynec, 11, 660-663, May, 1926
- ¹⁰ Sheppe, W F An Unusual Gunshot Wound of the Inferior Vena Cava J A M A, 78, 1890, June 17, 1922
- ¹¹ Wakefield, E G, and Mayo, C W Obstruction of Vena Cava Distal to Renal Veins Col Papers of the Mayo Clinic, 25, 644-651, 1933
- ¹² Walters, W, and Priestly, J T Surgery of the Inferior Vena Cava ANNALS OF SURGERY, 99, 167-177, January, 1934
- ¹³ Wurzel, P Gunshot Wound of the Inferior Vena Cava Cured by Suture of the Vein Časop lek česk, 70, 919-920, June 26, 1931

MEMOIR

HARVEY (WILLIAMS*) CUSHING

1869-1939

FELLOW, AMERICAN SURGICAL ASSOCIATION, 1906-1939

PRESIDENT, AMERICAN SURGICAL ASSOCIATION, 1926

"To study the phenomena of disease without books is to sail an uncharted sea, while to study books without patients is not to go to sea at all"

William Osler

THE DEATH of Harvey Cushing from coronary occlusion at New Haven, Connecticut, October 7, 1939, is of special significance to the Fellows of the American Surgical Association. Among the members of this group he counted his chief friends and from the time he became a Fellow until his death, he was a regular attendant at the Association's meetings as well as a frequent contributor of scientific articles. He liked the informal contacts which form such a valuable part of the meetings of the Association. On these occasions he often tried out, usually quite unheralded to his friends, new ideas which had occurred to him concerning either scientific problems or educational matters. He was keenly interested in the progress of his pupils as they joined the Association and was apt to single out these young men to congratulate them or to show an interest in their work whenever he had the opportunity. We who saw him thus intimately and came to know him better than did others, except perhaps his pupils and immediate associates, recognized his great abilities and the stimulus which his qualities gave to the Fellows of this Association. Fully conscious of his tremendous energy and restless disposition, we saw him reach for and attain achievement after achievement, only to marvel that long before one ambition was accomplished another and greater undertaking was already on its way. We are happy to inscribe here our deep admiration for his great qualities which led him to decorate the American surgery of his time. Although he was widely acclaimed as a superb surgeon, a scientific investigator, a great writer, and a medical historian, we, his intimates, benefited equally from the example he set in the care of sick people. He is no longer with us,

* The Williams, his maternal ancestor's name, was finally dropped after his settling in Boston in 1912, where his mail often became confused with that of a surgical colleague, Dr. Hayward Warren Cushing. But an even earlier episode had warned him of this difficulty, for, in 1895, when he had taken the examination for house-pupil at the Massachusetts General Hospital, he failed to hear the result for a long time after the other candidates had been notified. Investigation revealed that his notice of successful application, which seemed all-important to him at that time, had been forwarded to the same Dr. Hayward Warren Cushing, one of the most promising younger surgeons of Boston. This first incident was probably a major influence in his dropping the use of his middle name in his publications as early as 1900.



Harvey Cushing

but these qualities will surely be passed on as a part of the tradition of American surgery, and thus his influence will ameliorate the suffering of the sick in the generations to come

Born in Cleveland, Ohio, April 8, 1869, of a long line of distinguished doctor folk, he came from a typical New England family. His first American ancestor, Matthew, landed in Hingham, Massachusetts, in 1638. Many of his external and spiritual characteristics revealed a stern New England background. He appeared as a reserved individual, holding himself, as a rule, aloof from others in a great crowd, though unbending genially in the company of his friends. The austere and aristocratic portions of his disposition mirror many of our most distinguished American people, who came from the same Puritanic stock. The ancestors of such people were firm in their personal convictions, and stiffnecked and stubborn enough to venture into an unknown country and face great dangers rather than give in to the desires of others. But the Puritans had many attributes, and just as they appeared austere, so in their intimate contacts they often let themselves go and became the warmest of friends. Thus, when they can be approached, hidden qualities of geniality and friendship are displayed which frequently outshine characteristics carried by others more openly on their sleeves. Of such a mixture was Harvey Cushing—apparently stern, a severe taskmaster, more critical of himself than of others, and yet on occasions imbued with a warmth and geniality that astonished all but those who knew him intimately. We who had this privilege are grateful that such an ardent and busy nature should vouchsafe to us the preservation of his friendship.

Following his preliminary education in Cleveland, Ohio, he went to Yale College, where his prowess as a baseball player led him to make his Letter and later to become captain of the team. From Yale College he went to Harvard Medical School, where he graduated with the degrees M.D., *cum laude*, and M.A., in 1895. A review of his grades at the Harvard Medical School is of some interest, for the C minus in Clinical Surgery is in sharp contrast to the eleven A's and three B's. To understand this, one must realize that there was little opportunity for the students of that day to come into close contact with patients in their routine teaching exercises. To obviate this, many students neglected the regular course and spent their time as assistants or "strickers" in hospitals, thereby incurring the displeasure of the teacher thus neglected. At least such action expressed early the independence of Harvey Cushing's mind.

From the Harvard Medical School he went to the Massachusetts General Hospital as house officer on the Surgical Service. Here his industry and his beautiful records, illustrated by his own drawings, set him aside as an unusual person. Here he became interested in the early roentgenographic machine then just beginning to be used in cases of broken bones. And here he and Amory Codman kept records on special charts, drawn by Cushing, of the progress of patients during anesthesia, records which are to-day looked upon as one of the earliest attempts to set down in visual form the progress of a patient during a surgical operation. Later on, when he had brought back from Italy

a blood pressure apparatus with an inflatable armlet, there really commenced the first intelligent anesthesia charts which have been such an important addition to careful surgery. During his house officership at the Massachusetts General Hospital, he wrote a letter to his friend, W. S. Thayer, then working in the Johns Hopkins Hospital, asking him if by any chance there would be an opening available under Osler, when he was through his service in Boston. This letter to Thayer was never answered, and had it received favorable reception one simply cannot visualize the difference it might have made in Cushing's career. It would be an interesting matter, indeed, to circularize the American Surgical Association to see what answer our Fellows would have to this problem! Could a man of Harvey Cushing's make-up have been content with medical practice? Would he have found, possibly in the field of neurology, an interest sufficient to absorb all his energy? Would any career in medicine have had a practical enough appeal to a man who found a chief interest in keeping the mortality score of his work and who loved to do physical battle in the accomplishment of his surgical practice?

From Boston he went to Baltimore as assistant on the staff of William Stewart Halsted. Many of you have heard Doctor Cushing himself tell the story of his transition, but since the impact of Halsted's teaching is one of the turning points in his career and indeed one of the few instances where another's influence helped so obviously in charting the future course of his career, it may not be amiss to review the matter. The shift from the Boston surgery of that day, where speed of operating was still considered advisable and even used as a gauge of ability, to the painstaking, slow, and gentle methods of Halsted was an everlasting inspiration to the pupil Cushing. He often told the story himself that, coming from Boston where a complete breast procedure was accomplished in 28 minutes, he saw with misgivings a four and one-half-hour operation for the same undertaking. How amazed he was that stimulants were unnecessary, and how horrified he was when told not to dress the wound for ten days! Recalling the wounds he had previously studied, he remarked to himself, "I may not see the wound, but I shall smell it!" When in ten days the wound was dressed and found perfectly healed, his skepticism disappeared. Moreover, here he was first introduced to the experimental method, and was taught the value of careful and detailed records whether in the laboratory or on the ward. From Halsted he learned that precise and thorough concentration on a small problem might yield more than great labors in routine work. Here, too, he learned the value of a meticulous and gentle technic that sought to spare each cell from being damaged, a technic which was to permit him in the years to come to create the surgery of the central nervous system. It is doubtful if Halsted had any other pupil who learned so rapidly and thoroughly the art of surgery as he, Halsted, conceived it.

Finally, his training as a general surgeon completed, Doctor Cushing went abroad (1900-1901), and in Berne, through Kocher and Hugo Kronecker, accomplished his first work in experimental neurology (*Physiologische und*

anatomische Beobachtungen über einige hiermit verwandte Erscheinungen Mitt a d Grenzgeb d Med u Chr, 9, 773-808, 1902) This neurologic field was to become his life work, and it is of interest to examine the stimulus which brought him to it My notes made after conversations with Doctor Cushing led me to feel that Doctor Halsted suggested to him the field of neurologic surgery, but recently Dr Roy D McClure, who worked with Doctor Cushing during the first year that the Hunterian Laboratory was open and who became later Halsted's Resident Surgeon, and others have made it certain that Harvey Cushing himself proposed the field to Doctor Halsted Doctor Halsted's first reply was, "Why Doctor Cushing, we had only two cases of brain tumor last year!" When Doctor Cushing persisted, Doctor Halsted remarked, "All right, the field is yours" And perhaps there were indications of this leaning even earlier, for the title of Doctor Cushing's second paper was "Haematomyelia from Gunshot Wounds of the Spine A Report of Two Cases, with Recovery Following Symptoms of HemileSION of the Cord" (Am Jour Med Sci, 115, 654-683, June, 1898) This article was spoken of by Doctor Thomas, then Professor of Neurology at the Johns Hopkins Medical School, as the best investigation of superficial sensory supply carried out up to that time

During his first trip to Europe, Harvey Cushing picked up in Pavia, Italy, a clinical model of Riva-Rocci's blood pressure apparatus with an inflatable armlet, which he adopted for use in all his subsequent surgical procedures This is of special interest, for this apparatus led to a cementing of the friendship between Cushing and George Crile and thus, indirectly, to the founding of the Society of Clinical Surgery, a traveling clinical club in which these two were among the motivating spirits

On his return from Europe, Cushing became the Neurosurgeon of the Johns Hopkins Hospital group It was a difficult and discouraging beginning The mortality was terrific, though better than that obtained by other surgeons Always there was extreme diligence and thoroughness Autopsies were secured whenever possible The reasons for catastrophes were thus explained and technical perfection thus secured The happier field of the surgical treatment of trifacial neuralgia was reopened, studied, and made safe Laboratory efforts previously in the field of general surgery continued in this newer field and soon he began to investigate the pituitary body Tumors of it were noticed, studies of its functions grew apace, and by the time of his removal to Boston, his first book appeared, "The Pituitary Body and Its Disorders"

During these formative years in Baltimore, when his work hardened entirely along neurophysiologic lines, he discovered in William Osler a chief stimulus and mentor They were next-door neighbors, and his footsteps were often turned to Osler's home where he found encouragement, guidance, and leaven which only such a brilliant character could give Here he began to acquire his love of books and his amazing information of the background of medical history Here he gathered in acquaintances from many corners of the

world to emerge a real cosmopolitan Osler's departure to Oxford, in 1905, seemed a great loss to Harvey Cushing, but by this time he was well started in his bibliophilic adventures and perhaps was really benefited by the independence of thought and action which this separation enforced Anyway, the trail between these two was now well established, and their correspondence formed a major tie of interest for each until Osler died

It will be of some interest for you to know that as early as 1910 Harvey Cushing was appointed Professor of Surgery at the Harvard Medical School and Surgeon-in-Chief at the Peter Bent Brigham Hospital The new Harvard Medical School was occupied in 1906, and some wise heads had influenced the Board of Trustees, under the will of Peter Bent Brigham, to build an hospital on the cow pasture adjoining this new school Cushing never taught under this title because, by the time he moved to Boston, in 1912, Maurice Richardson had died, and his title was changed to Moseley Professor of Surgery In January, 1913, the new Peter Bent Brigham Hospital opened its doors and his labors in Boston began in earnest The details of his accomplishments in Boston are available to all in the Annual Reports of the Hospital It is appropriate to point out here that Harvey Cushing and his colleague, Henry Christian, put great emphasis on the value of professional hospital reports Here they reviewed and prophesied the changing character of both medical education and medical practice, and thus elevated hospital reports to a useful professional level

At first he kept his interest in the general surgical clinic, but his prominence in neurosurgery was so outstanding that gradually this field occupied all his energy and time Yet, in spite of these responsibilities, there was at first time for tennis and frequent discussions with the devoted members of his house staff Indeed, it was these informal meetings, plus his weekly rounds on patients with other than neurologic disorders, and the influence of his great example in the care of his own neurologic patients which permitted him to be the major influence, for many years to come, on many pupils whose interest lay in the field of general surgery And from time to time he did take on the performance of some unusual task in the field of general surgery, and such procedures will long be remembered by the interns of the first few years of the Brigham Hospital as among their greatest moments of inspiration Before the Great War was upon us, he had become one of the leading surgeons of our day, a matter attested to by the invitation to give the oration in Surgery at the International Congress of Medicine in London in 1913, "Realignment in Greater Medicine, Their Effect upon Surgery and the Influence of Surgery upon Them" (*Brit Med Jour*, 2, 290-297, August 9, 1913 Also *Lancet*, 2, 369-375, August 9, 1913)

Then came the war, and for Doctor Cushing two experiences, one with the French Army at the American Ambulance Hospital in Paris, April, 1915,*

* At the outbreak of the European War, Americans in Paris organized the American Ambulance Hospital under the auspices of the American Hospital, a small incorporated hospital largely used by the American colony there The French Government placed the new Lycee Pasteur in Neuilly at the disposal of this new Ambulance Hospital One of

and later, after the United States had entered the war, with Base Hospital No 5 in France, May, 1917 to May, 1919. His great abilities soon led to his removal from this Base Hospital group, of which he was the organizer and peace-time Director, to become the senior consultant in neurosurgery of the American Expeditionary Force. During these experiences his tremendous labors under the severe physical strain of forward conditions brought comfort and life to many an injured soldier, but his unsparing devotion to the task eventually undermined his health and left him a sufferer from arterial disease for the remainder of his life. All through this period of immense physical strain, his publications continued. His contributions to the care of intracranial war wounds set the proper methods in this field. Great as was his devotion to professional work, he found time to keep up his daily Journal, a habit begun in youth and continued throughout his life whenever he traveled away from home. In 1936, excerpts from his daily War Journal appeared in book form, *From a Surgeon's Journal* (Boston, Little, Brown, and Company, 1936). For his great works in France he was honored by his own country by the award of a Distinguished Service Medal, by Great Britain by the Order of the Companion of the Bath, and by France with the position, Officer of the Legion of Honor.

During this war experience there were several trips to England, and each time the long desired visits with Osler. On one of these occasions the writer was present and recalls as brightly as if it were but yesterday the witty and brilliant chaffing which flowed forth at the time. It was shortly before Revere Osler's death, and though the imminence of disaster seemed in the very air, the comfort and happiness of the guests was overwhelming. Conversation drifted from the first written medical document, a piece of stone covered with unknown writing this time, to how difficult it was for the British to learn the value of corn as food for man, having for centuries thought it fit only for pigs and chickens! All the time Harvey Cushing sat wrapped in devoted and appreciative silence.

After the war he became reestablished in Boston and his labors in neurosurgery took on their final form. His interest in general surgery lagged, for there was no time for it. Assistants flocked to his side to work in neurology and neurosurgery, and the output of their work and influence is world-wide. In the midst of all this William Osler died, and, at the request of Lady Osler, Cushing took up the writing of a biography. It was a labor of love, but it was accomplished with the same tools and vigor that surrounded all Harvey Cushing's works. First every possible source of information was gathered in and digested, the smallest references in daily newspapers were consulted,

the three services was organized to be staffed by groups which rotated every three months from American Medical School hospitals. A unit under Dr. George Crile, from the Lakeside Hospital, Cleveland, Ohio, began this service January 1, 1915, the Harvard Medical School unit followed, April-June, 1915, and was in turn followed by a unit from the University of Pennsylvania Medical School. Doctor Cushing remained with his unit only for the month of April, 1915, returning via England where he visited Sir William Osler.

and from this background the great two-volume biography appeared. Small wonder to those who knew of the sincere efforts that the product would be so universally acclaimed.

On the occasion of his sixtieth birthday, 1929, his pupils dedicated to him a collection of their writings. This "Festschrift," a special number in honor of Harvey Cushing's sixtieth birthday (*Arch Surg*, 18, 935-2045, 1929), emphasized his qualities as a teacher. The 82 papers were contributed by men then holding some of the most important medical and surgical positions not only in the United States of America but in Europe. And the contributions not only were in the field of neurology and neurologic surgery but ranged over the entire field of medicine, and included historical essays as well as experimental and clinical observations. The impact of Cushing's character and abilities is nowhere better pictured than in this affectionate tribute.

His effect upon the Harvard Medical School Faculty was considerable, even though he and the Dean of the School during this period did not always agree in matters of policy and action. Cushing was greatly interested in the establishment of a common library, in the modification of the curriculum with its resultant reduction in didactic hours, and was a leader in opposing the adoption of the "full-time clinical teaching" in the strict Rockefellerian sense and in opposing a plan that the Medical School edit a text-book which purposed to infiltrate all departments of the School with preventive medicine.

The hospital regulation set by himself and Henry Christian automatically retires the professional members of the Brigham Hospital staff at the age of 63, and this, by custom, is accompanied by resignation from the Medical School appointment. And so, in 1932, arrived the date of retirement set by himself. It came at a time when Doctor Cushing was working as never before, though bothered with peripheral vascular disease and the signs and symptoms of gastric ulcer. The transition from his tremendously active life was great, but he made it abruptly, and surgery was given up. He refused the repeated requests of the Brigham Hospital Trustees to remain in service as Surgeon-in-Chief, and attempts were soon made to entice him to many places, though it was hoped he would stay in Boston and work on his collection of brain tumors. He remained at the hospital for another year, however, and worked in uncomfortable quarters, for he insisted that his successor occupy immediately the quarters set aside for the Surgeon-in-Chief. The following year he went to Yale as the Sterling Professor of Neurology (1933-1937). Here he was offered an active post, not simply an honorary sinecure, and to a man in the full vigor of his years, this opportunity and his natural devotion to his Alma Mater, which had the vision to utilize his great abilities, turned his footsteps away from Boston and Harvard. With him went his collection of brain tumor specimens and photostatic copies of the patient's records. At Yale he continued a thorough study of this great mass of material, the assembling of which represented such unusual physical efforts. Major fragments of this material had appeared either in book form, as the monograph on the acoustic neuromata (1917) and the classification of the gliomata with P

Bailey (1926), or in separate smaller publications, notable among these being his final contribution in the field of pituitary disorders "basophilism," a clinical syndrome which now bears his name. At Yale, the work continued in spite of frequent physical discomforts. Clinical, experimental, and historical papers continued. But chiefly there was the continued study of his own experiences in the field of brain tumors and always there went on the follow-up and end-result letters and examinations*. Though the Yale professorship terminated in 1937, the work continued unabated, and he was as active from 1937 up to the time he died as at any time in the last five years. The great volume on the meningiomata did not appear until 1938.

This brief glimpse into the life and works of a man who was a friend to everyone here must leave us somewhat stunned by the breadth and profundity of his accomplishments. We knew him as an individual, endowed with unusual ability, ambition, and artistic temperament. We have seen personally the technical perfection of his surgical art, and we have marveled that, in the brief span of a single existence, he was able to accomplish such a mass of high grade endeavor. His abiding curiosity was one of his outstanding qualities and one which constantly led him to intellectual pursuits, often quite unassociated with his professional career. Such a curiosity certainly played a rôle in his acquisition of a great medical library. Take, for example, a book given to him by a friend or a grateful patient. As soon as he had it, he had to know who had owned it before his hands touched it, then all about the author and all about the printer. If any of these was one who had left his mark in the passage of time, then Cushing would ferret about until he knew a good deal about that particular individual. The same was true about things he noticed when traveling. Doctor Councilman was once trying to explain to me, with the aid of a small pocket lens, the difference between the leaves of the various conifers, and for a whole week Doctor Cushing kept at Councilman until he thoroughly understood the details of this simple study into the works of nature.

To many people he was looked upon as a great teacher, and here indeed lay one of his greatest gifts to posterity, for no master has had a more devoted group of pupils, who so obviously have followed in emulation the footsteps of their master. His exquisite handling of tissues, his perfect care of the patient, his leaving no stone unturned no matter what the effort, were the lodestones which drew young men to him in great numbers. His method of teaching was simple. It was the apprenticeship system, and since Cushing was a man of few words, it was largely a teaching through example. It has often been said that Harvey Cushing was a severe task master. He was when it was necessary, but he certainly never demanded greater labors of his pupils.

* As late as July, 1939, a chromophobe pituitary adenoma patient seen first by Doctor Cushing in February, 1926, turned up at the Brigham Hospital to show the writer a letter from Doctor Cushing, inquiring about his condition, with the request that the writer examine him and send the information to Doctor Cushing. This done, there was the immediate grateful reply, so characteristic of his correspondence with a pupil.

than he set for himself, and it causes us no surprise that such an ardent and serious person was impatient with incompetence and slovenliness. His perfectionist attitude brooked no compacts with mediocrity, and throughout all his relations with his pupils there was always time for wise counsel and friendly advice. The pupils always knew, even without a spoken word, that their interests lay close to his heart.

He is survived by his widow, Katharine Stone Crowell, and four children, Mary, Betsy, Henry, and Barbara. Another son, William, the eldest child, was killed in an automobile accident while a student at Yale College. Mrs. Cushing was not a frequent visitor to the meetings of the American Surgical Association, though she did attend the meeting at Richmond when Harvey Cushing was our President. However, she was known to most of the Fellows of our time, for Harvey Cushing almost always had people home to dinner with him when they visited Boston, and on these occasions Mrs. Cushing was the perfect hostess, always interested in the visitor's point of view, and putting him at rest and in comfort through her simple, direct, and thoughtful nature. Fellows of the American Surgical Association who were at one time pupils of Doctor Cushing came to know Mrs. Cushing intimately, and all of these shall forever feel their indebtedness to her for much help and kindness as they climbed the surgical ladder at the Brigham Hospital. We are happy to record here, at a time when we mourn greatly the loss of our friend, our special affection to her who did so much for many members of this association.

We who have so greatly enjoyed our fellowship with Harvey Cushing and profited by this relationship are happy to acknowledge here our admiration for one whose work will descend through posterity for the benefit of mankind. We, his friends, recognize in many of his attitudes and actions the natural ambition of all people, and though we may see less of the supernatural than others, recognize his unusual accomplishments. Through my long and devoted association with him, I believe that he would like best of all to have said about him that he had followed the highest tradition of our profession—that he never had neglected anything that could bring comfort or benefit to a patient. These attributes made him not only a master surgeon but a chief physician of his time.

ELLIOTT CUTLER

EDITORIAL ADDRESS

Original typed manuscripts and illustrations submitted to this Journal should be forwarded prepaid, at the author's risk, to the Chairman of the Editorial Board of the ANNALS OF SURGERY

Walter Estell Lee, M D
1833 Pine Street, Philadelphia, Pa

Contributions in a foreign language when accepted will be translated and published in English

Exchanges and Books for Review should be sent to James T. Pilcher, M D, Managing Editor, 121 Gates Avenue, Brooklyn, N Y

Subscriptions, advertising and all business communications should be addressed

ANNALS OF SURGERY
227 South Sixth Street, Philadelphia, Pa

ANNALS OF SURGERY

VOL 111

MAY, 1940

No 5



TRANSACTIONS OF THE SOUTHERN SURGICAL ASSOCIATION

MEETING HELD AT AUGUSTA, GA
DECEMBER 5, 6, 7, 1939

ADDRESS OF THE PRESIDENT

THE SURGEON IN THE ROMANTIC STORY OF TEXAS*

ALBERT O SINGLETON, M D

GALVESTON, TEXAS

PREVIOUS Presidential Addresses of this Association have been in the form of scientific papers, philosophic discussions on surgery as a science and profession, and those with a historic background. Most of you have witnessed my best efforts with a scientific paper, and I lack the ego and courage to venture my beliefs or views upon the problem of surgery as a whole, so I have taken the easiest course and will endeavor to give you some of the high lights of the romantic history of Texas, including its no less romantic surgical history.

In March, 1536, 400 years ago, a party of Spaniards from Mexico (New Spain), scouting in the wild lands near the Gulf of California, suddenly came upon a spectacle more strange and unexpected than the footprints which greeted Robinson Crusoe's eyes on his desert island. It was a white man, all but naked, his nakedness partly concealed by a tangle of long hair. He was accompanied by a Moor slave, Estebanico, two Spanish companions, Dorantes and Castello, and eleven Indians, his name was Álvar Núñez Cabeza de Vaca (Fig 1).

These were the survivors of a Spanish expedition of 600 men led by Narvaez, who, searching for gold, plunged into the Florida swamps in 1527, expecting to reach New Spain (Mexico) overland and by sea. But disaster rode their sails. Storms wrecked their ships, one of which was on an island off Matagorda Bay, on the coast of Texas, November 6, 1528. Indians

* Delivered at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

seized the shipwrecked Spaniards and made slaves of them. This was turning the tables with a vengeance, as a favorite practice of the Spanish conquistador was to enslave the Indians. These were the first white men to reach Texas soil, and the leader of the party, Cabeza de Vaca, became the first surgeon in Texas.

While slaves of the Indians, the tribe was visited by an epidemic disease of the bowels and half their number died. The Indians demanded that the white men stop the disease, and rather than lose his scalp, de Vaca accepted the medical degree. Magic, prayer, Indian medicine, cauterization, cupping, herbs and concoctions obtained from the Indians were his remedies. Soon he and his companions were followed by a worshipful crowd of sick and crippled,

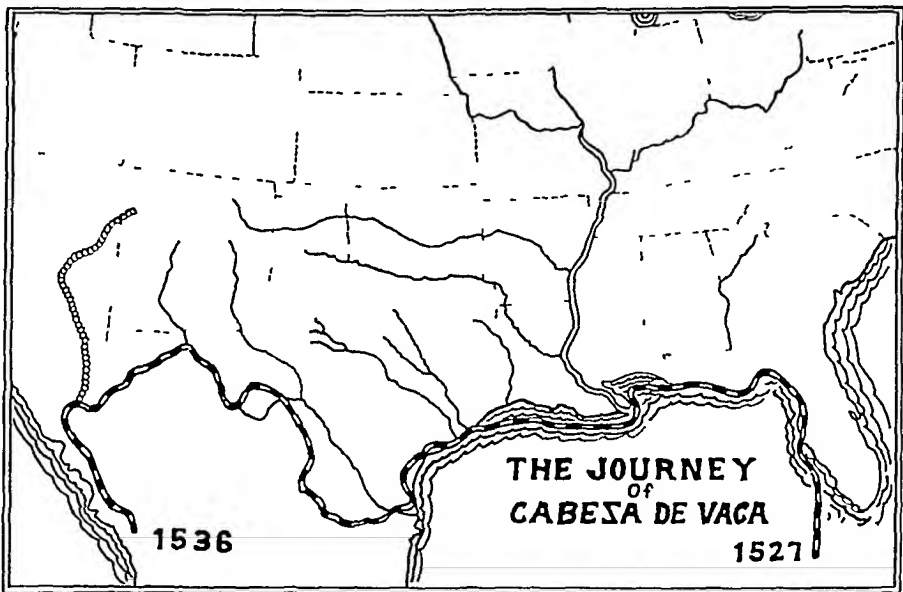


FIG. 1.—The route of De Vaca in journey of 9 years across America.

and in his story de Vaca tells of the many blind and diseased Indians he treated. He also describes an operation he performed in 1535: "Here they brought me a man, who, they said, a long time ago, wounded by an arrow, the point of the arrow above the heart. With a knife I carried, I opened the breast. I continued to cut and drew the head forth. With a deer bone I made two stitches and with the hair from a skin I stanching the flow of blood. The whole village came to look at the arrow. I cut the stitches and the Indian was well" (Fig. 2).

This was unquestionably the first surgical operation performed in Texas. It was 404 years ago and, at the same time, in the Old World, Vesalius was teaching anatomy and pointing out Galen's anatomic errors, and Leonardo da Vinci was painting the Mona Lisa. Also, Ambroise Pare, with little more medical training than de Vaca, was making surgical history through the school of experience. With the passing of de Vaca across Texas, Spain claimed the country, though no white man remained.

THE FRENCH IN TEXAS—One hundred fifty years later, this strange new

country was for all intents and purposes discovered again, and this time by a Frenchman. In 1685, Robert Caveliers de La Salle, one of the greatest of explorers, sailed down the Mississippi River to its mouth, laying claim to the great valley for France and calling it Louisiana (Fig 3). One year later, on an uncharted sea, his ships missed their goal, which was the mouth of the Mississippi, striking the gulf coast at the west end of Galveston Island. A tropical storm wrecked the fleet on the same spot on which Cabeza de Vaca's Spaniards met disaster 150 years before. Disease and dissension arose among the stranded Frenchmen, and the great La Salle was murdered by some of his rebellious followers, led by his surgeon, Liotot, the second surgeon recorded in Texas. La Salle was troubled by a hernia but it was not operated upon.



FIG 2—DeVaca was followed by a worshipful crowd of sick and diseased Indians

Joutel, a priest, surviving the expedition says "A soldier while retrieving a snipe shot in a marsh, was bitten on the leg by a rattlesnake. Five months later his leg still swelling, the surgeon, apprehensive of mortification, cut it off. But fever followed immediately and he lived but two days, dying on the Feast of the Decollation of St John the Baptist much lamented by all and particularly by Monsieur La Salle." This was the first amputation performed in Texas with a mortality of 100 per cent to the patient, and also the surgeon who soon afterwards was assassinated. La Salle's expedition ended the first and only effort by France to colonize Texas.

SPANISH MISSIONS IN TEXAS—Spain, fearing that the French would colonize the new country, sent an expedition, formed in Mexico, to settle here. This was in 1716, and in the next few years, many missions were established, the most famous of these was the historic Alamo (Fig 4).

The missionary zeal of the padres was persistent but little headway could be made with the Indians. Only so long as corn and clothes were given them were they good Christians. Out on the plains roamed the fierce Comanches (Fig 5) and Apaches, whose war cry brought terror to many white men, and the colonies did not prosper. The Spanish padre was filled with zeal for the salvation of the heathen souls, but nothing could speak more eloquently of the failure of Christianizing the Indian than the ruins of the Spanish missions, to be seen over Texas some 50 years later, and now.



La Salle's Landing in Texas

FIG 3

In 1762, following the French and Indian wars, rather than lose them to England, France secretly transferred all her claims to Texas and Louisiana to Spain, and Galvez, the young Spanish governor of Louisiana, became Governor of Texas as well.

At the turn of the century, Napoleon was flying high and in order to curry favor with him, Spain secretly transferred the Louisiana territory back to France. But Napoleon needed money more than wild Indians, and two years later, sold Louisiana to the United States. But Spain held on to Texas and though her claim was questioned, it was respected.

"The Spaniards were never quite happy in any part of the New World—where profit was to be had only as the reward of their own labor. They were

not natural colonizers and developers like the English, nor traders and diplomats like the French. They were conquerors, rulers and exploiters. They were never comfortable in the neighborhood of the hostile Indian because the Indian refused to be conquered."

THE COMING OF AMERICAN SETTLERS—The fertile plains of Texas were inviting to the Americans to the east and north who had begun to have growing pains after gaining their independence from England. Settlers began to sweep over the border and they were not the most peaceful settlers. In 1820 the Spanish authorities found it necessary to drive out a filibustering party under Dr. James Long, called by General Jackson at the Battle of New Orleans "my young lion." In a battle with the Kiankaway Indians on Galveston Island, his associate, Doctor Pinnell, had his cap pinned to his scalp by an arrow. Lamar records that "the arrow was extricated from the scalp



FIG 4—Historic Alamo, 1716



FIG 5—Fierce Comanche Indians (Remington)

'*secundum artem*' by Gen. Long with his broken sword." Thus another surgeon in Texas was not remembered for his scientific achievements. Also, the American buccaneer, Jean Lafitte, driven from New Orleans, had become established on Galveston Island from whence he was making war on Spanish ships. In spite of these events, Moses Austin was given a grant to settle 300 families. His 28-year-old son, Stephen, executed this first grant for settling Americans in Texas.

Stephen Austin was truly the Father of Texas, cultured, wise, persistent and faithful to his trust. Barker says of him "He was successful with none of the tricks of the demagogue. His influence was based upon his recognized knowledge, wisdom and character."

In 1821, Mexico had gained her freedom from Spain, and in 1827, Santa Anna, an unprincipled leader, became President of Mexico. Considering himself the Napoleon of the West, he began to march into Texas to put down a rebellion of American settlers. Austin made haste to Mexico to intercede for the colonies but the only satisfaction he got was a year in prison. In 1835, he reached home to be followed by Santa Anna's army. The peaceful Austin now became aroused to the necessity for armed resistance, called the settlers together, declared their independence and declared war.

At this time there appeared upon the scene a man of destiny, Sam Houston, to continue his romantic exploits. "He had just come triumphantly

through a sensational affair in which he had bested the enemies of President Jackson in the U S Congress For three years, ever since he had separated from his bride of only a few days and had resigned from the office of Governor of Tennessee, Houston had been under cloud " During this time he had lived with the Cherokee Indians on the Arkansas River, and he was regarded as, he has said of himself, "a man of broken fortune and blasted reputation" In 1830, he had come from his retirement and had endeavored, through President Jackson's influence, to help the Indians



FIG 6—Fall of the Alamo 1836

Resenting an attack upon the President by Congressman Stonbury, of Ohio, he challenged him to a duel Stonbury refused to duel, and upon being met by Houston on the street was thrashed with a cane Houston was tried before the Bar of the House, the trial lasted a month and created a great sensation Houston, referring to it, said "I was dying out and had they taken me before the Justice of the Peace and fined me ten dollars for assault and battery, it would have killed me, but they gave me a national tribunal for a theatre, and that set me up again"

Houston, who was made Commander-in-Chief of the Texas Army, issued a call to arms October 8 1835 Santa Anna's army was soon at San Antonio, and a hurried call was sent to Houston, 200 miles away, for help, but no help could reach San Antonio The small garrison of Texans could have escaped, but a council of war between the leaders, Col Travis, Col Bowie and David Crockett, decided to defend the city Gathering all within the Alamo, the old mission converted into a fort, with a few cattle for beef and a quantity of

corn, they prepared for a siege. A messenger slipped away with Travis one last appeal addressed "To the People of Texas and All Americans in the World—Fellow Citizens and Compatriots. I am besieged by a thousand or more Mexicans under Santa Anna. I have sustained a continual bombardment and cannonade for 24 hours and have not lost a man. The enemy has demanded a surrender at discretion, otherwise the garrison are to be put to the sword, if the fort is taken. I have answered the demand with a cannon shot and our flag still waves proudly from the walls. *I shall never surrender or retreat.*"

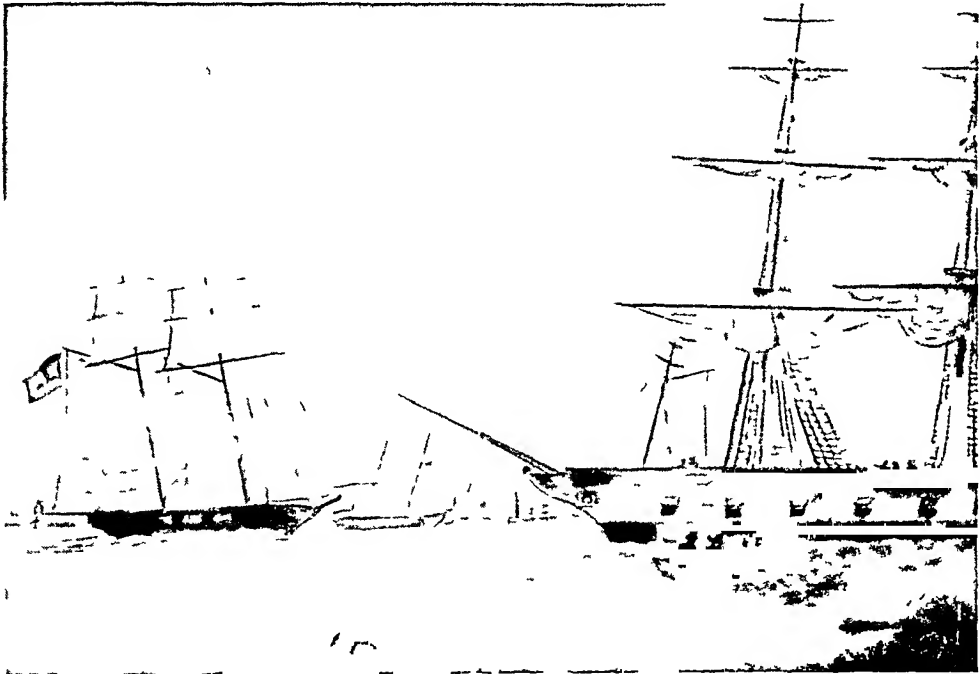


FIG 7—The Texas Navy, 1835

For two weeks the little band of Texans held the fort against Santa Anna with an army grown to 4,000 men. On March 6, 1836, the fort was in ruins. The Mexicans forced the walls, Travis fell, shot through the head (Fig 6). Bowie, who lay sick on a cot, raised himself up in bed, hauled his keen knife at the heart of the first man to face him and fell back dead. Davy Crockett was found with 20 dead Mexicans around him. Three women, a child and a Negro servant were all that fell into the hands of the victors. These were shot by order of Santa Anna. A commemorative tablet at the Alamo bears the legend "Thermopylae had its messenger of defeat, the Alamo had none." One hundred eight-two Texans were buried in one grave. Fifteen hundred Mexicans were killed during the siege. A few days later, 400 men, at Goliad, under Col. Fannin, surrendered to a force of 600 Mexicans. Upon Santa Anna's order all were shot.

The martyrs of the Alamo and Goliad did not die in vain. The Mexicans had been held at San Antonio for two weeks during which time the settlers were fleeing eastward, and Houston was struggling to raise an army to meet the Mexicans.

On April 21, 1836, the Texas Army refused to retreat further and, with Houston's generals urging a stand, they prepared to fight an army twice their number. A surprise attack was launched by the Texans, which caught the Mexican Army completely off guard. It was early afternoon and Santa Anna and his men were taking an afternoon siesta, when the Texas Army charged with the battle-cry "*Remember the Alamo—Remember Goliad!*"

The battle was a one-sided slaughter—380 Mexicans were killed, 730 captured, some 40 escaped. Two Texans were killed and 20 wounded. In searching over the prairie for Mexicans the next day, Santa Anna, the Napoleon of the West, was brought in disguised as a private. The revolution had succeeded and the REPUBLIC OF TEXAS was born. The Battle of San Jacinto

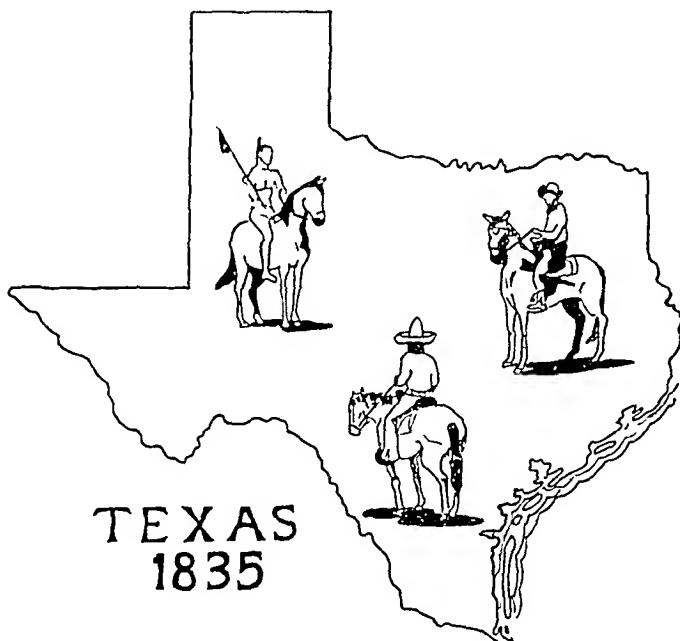


FIG. 8—TEXAS WAS OCCUPIED BY THREE Warring peoples

was one of the 16 decisive battles of history, for here was settled forever the separation of the Latin and Anglo-Saxon races in the New World. The largest monument of its kind in the world marks the battlefield.

THE LONE STAR REPUBLIC AND THE TEXAS NAVY—From 1836 to 1845, the Republic of Texas grew and prospered. For nine years it was a sovereign power, a power recognized by other powers, with her own constitution, army, navy, president and flag.

The Texas Navy was rapidly commissioned in 1835 to defend the gulf coast and prevent soldiers and supplies from reaching Santa Anna's Army as it traveled across Texas. The Texas fleet at the time consisted of the *Liberty*, a sloop of 80 tons, the *Independence*, 160 tons, the *Brutus*, 160 tons, and the *Invincible*, 180 tons (Fig. 7). They lived up to their high-sounding names, capturing many Mexican prizes, and successfully preventing support and supplies from reaching Santa Anna, and the little navy was unquestionably largely responsible for the victory of Sam Houston at San Jacinto.

The question of annexation was fiercely debated by Congress for several years because, if admitted to the Union, it would be another slave state, but President Polk signed the congressional bill, December 29, 1845, making Texas a State of the Union.

THE TEXAS RANGERS—"The Texan was a transplanted American, an out-runner of the American frontier, they were intelligent, cool and calculating. In 1835, Texas was occupied by three warlike peoples (Fig 8). The Indians held the undisputed possession of the Plains, the Mexicans held the Southwest, while the Anglo-Americans occupied the Central and Eastern portion. The *Texas Ranger* represented the Anglo-Americans in this conflict with the other two. They were small in number and in order to win they combined the fighting qualities of the three races." "A *Texas Ranger* could ride like a Mexican, trail like an Indian, shoot like a Tennessean, and fight like the devil."

For more than 100 years the Rangers have been the symbol of law in Texas. When the war began between the United States and Mexico, it was the rangers who led the way and won the Battle of Monterey for Zachary Taylor. General King, of Taylor's Staff, said of them "Hays and his rangers were not only the eyes and ears of General Taylor's Army but his right and left arm as well." And when the going got bad with General Scott's troops from Vera Cruz to Mexico City, the Rangers were sent for. General Allen Hitchcock, of Scott's Staff, said of them "Hays' Rangers have come, their appearance never to be forgotten, not any sort of uniform, but well-mounted and doubly well aimed. Each man has one or two Colt revolvers, besides ordinary pistols, a sword and every man a rifle. The Mexicans are terribly afraid of them." There are many famous men recorded among the leaders, and many accounts are given of their daring and bravery, not only against Mexicans and Indians, but against outlaws, cattle thieves, train robbers and bank robbers. Captain Bill McDonald, who became a friend of Theodore Roosevelt, and the bodyguard of Woodrow Wilson, was a typical example of a ranger captain. When asked to explain his courage, he said "No crook will stand up to a man when he is in the right, look him in the eye and keep on coming." On one occasion a riot, with many involved, caused the citizens of a Texas town to send hurriedly to the Governor for the Rangers. When the train arrived, only one ranger got off. He was met by an excited group who asked anxiously—"Where are the rest of the Rangers? We have a riot here." The Ranger quietly answered, "You ain't got but one riot, have you?"

THE TEXAS CATTLE AND THE TEXAS COWBOY—These have been the source of almost as many romantic stories and songs as the Rangers. Before the railroads reached Texas, great herds of 10-, 20- and even 30,000 head of "long-horns" were driven in one drove to Kansas, Colorado and California. The "Chisholm Trail," the "Goodnight Trail" and others were famous routes made by the early pioneers. Goodnight was one of the greatest of cattlemen. He drove herds from Fort Worth to Denver. Because of the Comanche Indians in the North he blazed a trail west to the Pecos River and north on

the west side of the Pecos Goodnight crossbred the buffalo and the Texas cow in an effort to develop a better beef He was not a physician but a great animal doctor His ingenuity was evident on many occasions In the long constant drive over the desert he found that the bulls were unable to keep up with the herd because of swelling of the testicles from trauma This condition he remedied by amputating the scrotum and sewing it up after pushing the testicles up into an undescended position The same operation has since been employed by the urologists

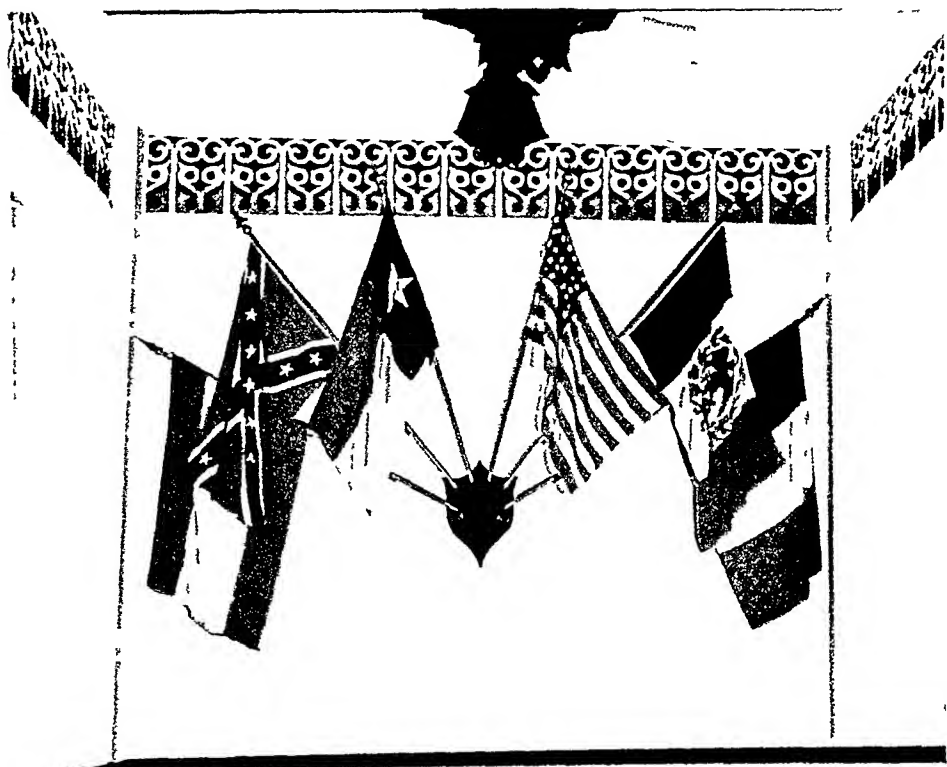
THE SURGEONS—Our narrative has become so long that there is little time for the SURGEON in Texas On the other hand, until more modern times he was of secondary importance Medicine from the time of the Missions to the American colonization is recorded in the Spanish archives and also in the records in Mexico It is recorded that the Indians suffered from disease and from many epidemics The white man brought measles, smallpox, typhus fever, bubonic plague and influenza, and they took a terrible toll of the Indians Syphilis, which supposedly was carried to Europe from the West Indies, probably was brought to the Texas Indian by the returning white man The Indian medical man was wholly ignorant and though some herbs were used, generally, tricks and faking were his stock in trade

Cabeza de Vaca's companion, the Moor, had already made medical history, for when he landed in Florida, in 1528, he came down with smallpox The new world was virgin soil and many Indians died of the scourge during the next 300 years

In 1798, Jenner discovered vaccination, and Charles IV of Spain, six years later, ordered that the vaccine be carried to Mexico and Texas A ship with children aboard set sail Two of the children were vaccinated each week with the virus taken from those vaccinated the previous week Thus the virus was kept alive and brought from Spain to her possessions in the New World

A most unusual Royal Decree from the King of Spain (found in Spanish archives) occurred in 1804 This was concerning the many spiritual and secular evils caused by not using the cesarean operation according to instructions This Decree defined clearly the duties and obligations of those responsible for labor cases, and the rules prescribed by the College of Surgeons of San Carlos are included in the Royal Cedula It provided that, in all towns, physicians should be on duty and be notified of the danger of death to patients in labor and every preparation made for a cesarean operation, and that they must not consent to the burial of anyone, regardless of class, dying of childbirth unless they knew that the operation had been performed upon her This Decree was sent to all the colonies in Texas

In San Antonio, the first Texas hospital was established in 1805, and it was in the famous Alamo, an abandoned mission building We find that, in 1815, King Ferdinand VII of Spain sent an interesting document to his Texas Colony inquiring as to the number of hospital beds, and whether or not surgical and medical cases were kept separate, also as to whether the doctors called regularly, and many other questions and orders were set forth



Texas under Six Flags

COLONIAL DOCTORS —During the colonial days we find records of epidemics of cholera, yellow fever and smallpox. There are also accounts of rattlesnake bites, but few accounts of surgeons of note. Austin's colonies were frequently without sufficient drugs and the services of physicians. The charlatan found a fertile field for martyrs but certain it is that Doctors Pollard and Michison, of Virginia, and Thompson, of North Carolina, achieved for the medical profession a portion of the glory of the Alamo where they died with their companions to whom they were administering to the end.

Attached to Fannin's command at Fohad were Drs J W Shackelford and Joseph H Baird of the 400 Texans treacherously massacred. Doctors Shackelford and Baird were spared that they might be utilized to treat the Mexican wounded.

A list of doctors who fought in the Battle of San Jacinto consists of 16. One of them, Dr Anson Jones, played a very distinguished part in the making of Texas, and was called the 'Architect of Annexation'. He was the last President of the Republic of Texas. He was a descendant of Oliver Cromwell. Doctor Jones was born in Massachusetts and was graduated from Jefferson Medical College.

With a new country filled with adventurers one naturally would not expect a high scientific development among the profession, and unquestionably surgery was extremely crude. Texas naturally could not expect to develop her own surgeons, and we find that their importation came chiefly from the medical schools of Philadelphia, Louisville and a certain number from European countries. European surgeons who emigrated to Texas had had the best training. Browsing over the literature of this period, one is struck by the ignorance of some surgeons, and, on the contrary, by the ability of others.

In 1858, an account of the transfusion of blood for yellow fever is quoted: "The patient was a lady in whom the yellow fever had reached the usually fatal stage when hemorrhage takes place from the mouth. She would have soon expired from loss of blood in that way, when Dr Benedict determined to try transfusion as a last recourse. The blood which he injected then, and afterwards, into her veins, he was careful to draw from the arm of a person (a volunteer) who had just recovered from yellow fever. This, we believe, is the only known case of transfusion in this city, but it is not likely to be the last. Indeed, it would not be surprising if that 'heroic' practice of phlebotomy (blood letting) was at a former period. It is obvious, however, that none but the most scientific and skillful should ever be suffered to undertake so delicate an operation" (Harrison Flagg, November 19, 1858).

The Texas State Medical Association was organized in 1853, and a report of the Committee on Surgery, 1872, is remarkable in its completeness and the amount of work expended upon it. Dr George Cupples, a brilliant surgeon, was Chairman of this Committee. The report summarizes 4,293 operations, with a mortality of 8 per cent. Of the 2,080 major operations there was a mortality of 15.9 per cent. It is interesting to note that of these cases there were 38 secondary hemorrhages, with eight deaths and 14 cases of

tetanus, following operation, with 12 deaths. Of the anesthetics which were employed in these operations, chloroform was in the lead with 3,178 cases, with one death before operation, no deaths during operation and alarming symptoms in only 12 patients. There were eight disarticulations at the hip joint, with a mortality of 50 per cent. There were 47 ligations of the arteries reported, among them being subclavian, axillary, brachial, common carotid, external iliac, common femoral and popliteal. Lithotomies in the male were 139, with a mortality of only 12 per cent, which, compared with the mortality in other operations reported, must have been more skillfully performed. Of these lithotomies, the lateral approach was employed in 81 cases, and the median in the remainder. The suprapubic operation was not practiced.

Many of the early surgeons deserve special mention, but time will permit of only a few. Dr. Ashbel Smith, a graduate of Yale, who came to Texas about the time of the Battle of San Jacinto, was a very close friend of Sam Houston, and was appointed Surgeon General of the Texas Army. His influence in the enactment of laws regulating the practice of medicine was needed and accepted. Also, he was the great spirit which caused the establishment of the University of Texas, and was Chairman of the first Board of Regents. He wrote upon many medical and surgical topics, he also became famous because of the assistance he gave as a collaborator of the American revised version of the Bible. He was Minister from the Texas Republic to the Court of St. James, he danced with Queen Victoria and lunched with Napoleon III. He spoke and wrote French easily, also Latin and Greek. At the beginning of the Civil War he raised the Second Texas Infantry and fought throughout the War. He was seriously wounded at the Battle of Shiloh.

Dr. George Cupples was probably the most outstanding surgeon in Texas at the time he lived. He was well educated, and never ceased in his endeavor to improve the condition of surgery. His father was Surgeon in the British Navy and he himself served as Assistant Surgeon in the British Army. He was graduated from the University of Edinburgh and studied extensively in London and Paris. He reached Texas about the time of the Mexican War and enlisted, serving throughout the War as a surgeon. He served as Senior Surgeon in the Seventh Texas Regiment during the War between the States.

Dr. Gideon Lindebaum, a doctor-botanist, wrote extensively of Indian medicine. He paid a medicine man to teach him the art, spending many weeks with the Indians. Later he listed 500 plants in Texas with medicinal properties, many of which were used by the Indians. He wrote extensively and urged castration of criminals, as did many doctors of his acquaintance and some politicians.

Dr. Greenville Dowell, a graduate of Jefferson Medical College, was another pioneer of great force. In 1865, he was elected to the Chair of Anatomy in the First Texas Medical School at Galveston. He devised an operation for the radical cure of hernia. He also devised a subcutaneous ligature for the cure of varicose veins. His instruments for extracting arrowheads and bullets were favorably known to all surgeons in his part of the country. He

was more of a worker than a writer, but he found time to conduct the *Galveston Medical Journal*, a monthly journal that started in 1866 and ended in 1871. His writings upon yellow fever and malaria were valuable contributions. In an editorial in his medical journal he called attention to the hordes of mosquitoes preceding and accompanying yellow fever epidemics, ten years before Dr. Finlay, of Cuba, published his theory of mosquito transmission of the disease. He was called to the cities of Memphis and New Orleans for the yellow fever epidemics in 1870, and, in appreciation, was presented with a gold medal by each city. He was Surgeon in Charge of the Hospital Department of the Southern Army.

Berthold Ernest Hadia was born in Germany in 1842, and received his medical education in Breslau and Berlin. He held the Chair of Surgery in the old Texas Medical College, and his contributions to medical literature were numerous. He contributed to surgery of the spine by adding wiring of the spinous processes, which was probably the first effort ever made at internal fixation of the vertebrae for tuberculosis of the spine. My distinguished friend, Dr. A. C. Scott, makes the following interesting statement in regard to him: "Dr. Hadia performed nine Kiasko operations for cancer of the rectum, and published his report of these cases. Dr. Nicholas Senn of Chicago became interested in Dr. Hadia's work and expressed a desire to have an interview with him. Accordingly, while in Texas, a visit to Dr. Hadia's office was arranged, and I had the pleasure of listening for about two hours to a detailed report of the cases. Dr. Hadia exhibited the pathologic specimens, each one of which was removed from the fruit jar in which it had been carefully preserved. There was much discussion between the two surgeons, part of which I could not understand because they often spoke in German, but I could tell that Dr. Senn was deeply interested and highly pleased with Dr. Hadia's work."

Dr. Ferdinand Heiff, of San Antonio, who died at the age of 91, was born in Germany in 1820. Becoming dissatisfied with the political conditions of Germany, Doctor Heiff led a colony to America. This colony formed the foundation for one of the most valuable citizenships Texas has had. He brought with him the culture and medical learning of Germany, which was far in advance of that of the New World. Doctor Heiff's career in Texas was a long and remarkable one, and, in 1854, he performed his first noteworthy operation. It was a lateral lithotomy upon a Texas Ranger. It was the first time Doctor Heiff had employed chloroform. The stertorous breathing of the patient, from the beginning of the operation, alarmed him to such an extent that the anesthesia was discontinued and the operation completed without an anesthetic. He performed his last operation at the age of 87 years. Probably no other surgeon in Texas can claim so many patients as he.

Dr. Bacon Saunders was a Past President of the Southern Surgical Association, and his activities were of such recent date, and his ability so well known to this organization, that it is unnecessary for me to mention his great influence in the surgery of Texas.

Doctor Saunders performed the first operation for appendicitis in Texas. This he did in a country home on a family dining table, his instruments sterilized on the kitchen stove. Wyeth's Surgery reports this as one of the first operations for appendicitis in the United States. I venture to say that Doctor Saunders did more heroic operations under similar circumstances than any surgeon Texas ever had.

Though a medical school had existed in Galveston since 1866, it was in 1891 that the University of Texas established a Medical Department. This was one year before Johns Hopkins Medical School was opened. A serious effort was made to secure an able faculty and fortune smiled upon the effort, for among the small group of teachers were four youngsters, 28 to 30 years of age, who became professors of important subjects, and who were truly the four horsemen of Texas Medical education. With little to begin with except youth, enthusiasm and brilliant minds, they soon developed an efficient teaching institution which filled a crying need—for qualified doctors were scarce in the rapidly developing country.

Dr. Allen J. Smith, a graduate of the University of Pennsylvania, was selected as Professor of Pathology and Dean of the new school. In 1895, he discovered the ova of the hookworm and lived to see the inestimable benefits accruing therefrom to our Southern states.

Dr. Edward Randall was Professor of Therapeutics. He was a Texan and was educated at Washington and Lee, and was graduated in Medicine from the University of Pennsylvania. Two years were spent in study at Vienna, Berlin and Paris. He retired from the faculty after 40 years and since that time has been a member of the Board of Regents of the University of Texas. He was not only the perfect physician but for the 49 years of the school's existence his wise guiding hand has ever been at the controls.

The third member of the group was Dr. William Keiller, born in Midlothian, Scotland, and a graduate of Edinburgh, becoming a lecturer in anatomy in that institution. He was later made a Fellow of the Royal College of Surgeons. Beginning with no equipment he developed one of the greatest anatomic teaching laboratories in America. He practiced surgery for quite a while but his soul was in anatomy, and for 40 years nothing could divert his interest. He wrote many theses on specialized anatomic subjects and published, in 1927, his book, *Nerve Tracts of the Brain and Cord*, which is considered a classic. He contributed 2,000 of his own anatomic drawings to the Anatomical Museum, which are invaluable aids in teaching.

The last name upon this roll of honor is that of Dr. James E. Thompson, a former President of the Southern Surgical Association. My close association with him as a student, and for 17 years as an associate in teaching, gives me the privilege of making more extensive comments, and I am sure because of his great life and enthusiasm for the Southern Surgical Association you will be sympathetic and forgive me if I say too much.

He was born in Norwich, England. His studies in surgery were completed in the clinics and hospitals of Vienna and Paris. He filled the Chair of

Surgey in the University of Texas for 36 years. He was a fellow of the Royal College of Surgeons and a member of the American Surgical Association.

As an anatomist, embryologist, pathologist, teacher and skilled surgeon he had no superiors and few equals. Especially notable was his work on *The Surgical Approach to the Bones of the Extremities*, which was reprinted by the United States Army for distribution to American surgeons during the World War. His articles upon cleft palate and harelip are classics in the literature of those subjects to-day.

He was a most interesting talker and his mind was a storehouse of knowledge ever open to his students, his assistants and colleagues seeking information pertaining to surgery in all its phases. He probably contributed his greatest good in the advancement of surgery in Texas and the Southwest. He was ever proud of the Southern Surgical Association and retained the highest admiration for its members, both collectively and individually.

I wish to acknowledge my dependence upon the following books for the story. I have drawn extensively from them, taking the liberty of quoting freely without giving direct reference to the authority. This is no doubt quite unpardonable. I am particularly appreciative of the assistance of my friend, Dr. Pat I. Nixon, from whose writings I have gotten valuable historic information. Also, I appreciate the privilege of reproducing Indian pictures from the Remington collection of Miss Ima and Mr. Michael Hogg.

REFERENCES

- Nixon, P. I. *A Century of Medicine in San Antonio*. 1936.
Idem. Liotot and Jalot, Two French Surgeons of Early Texas. *Southwestern Historical Quarterly*, July, 1939.
Roemer, F. *Texas 1849*. Translated by Mueller, 1935.
Bishop, Morris. *Odyssey of Cabeza de Vaca*. Century, 1933.
McSpadden, J. W. *Texas*. 1927.
Barker, Eugene. *Life of Stephen F. Austin*. 1933.
Webb, W. P. *The Texas Rangers*. 1935.
Molyneaux, Peter. *The Romantic Story of Texas*. 1936.
Red, G. P. *The Medicine Man in Texas*. 1930.
Idem. *The Texas Navy*.
Stuck, W. G. *Alvar Nunez Cabeza de Vaca, 1490-1564, First European Physician and Surgeon in the United States*. *Texas State Med. Jour.*, May, 1936.
Chapman, Arthur. "Out Where the West Begins"—From Songs of the Cattle Trail and Cow Camp. John A. Lomax. The Macmillan Co. 1931.

THE PRESENT STATUS OF THE "RADICAL OPERATION" FOR CARCINOMA OF THE BREAST*

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THERE has arisen, particularly during the past 10 years, a difference of opinion as to the effectiveness of the operative treatment for carcinoma of the breast. Objections to the routine employment of the "Halsted operation" have come from representatives of surgical clinics so influential that they cannot be disregarded. It has been stated that removal of the primary tumor with only a portion of the mammary gland gives as good results as the "radical operation." It has also been stated that treatment by radiation alone results in survival periods equal to those observed after the Halsted operation. Mitchiner, Bailey and Price¹ have recently analyzed the results of all of the operations for carcinoma of the breast in St. Thomas's Hospital (London) performed during a period of 20 years. Approximately one-fourth of these operations were limited to local excision of the primary tumor. After comparing the results obtained from the employment of the "Halsted" operation and the most conservative operations, these authors made the following statement:

"As a result of 20 years' figures on the cases of carcinoma of the breast operated upon in this hospital, it has been found that the mortality is practically the same whether the Halsted operation or the more conservative removal of the breast has been performed. It is urged in this article that the conservative and much less mutilating operation should be much more generally adopted in all cases of carcinoma of the breast."

During the 1937 meeting of the American Surgical Association, Geoffrey Keynes² presented the results he had obtained by the treatment of carcinoma of the breast by interstitial radiation. The survival periods of this series of cases compared favorably with any previous report of the results obtained by operation. Keynes' opinion of the effectiveness of the routine employment of the radical operation is presumably emphasized in his following recommendations, which I believe are contrary to the opinions generally held by American surgeons:

- (1) Local removal of the tumor if it is large, or the diagnosis is uncertain, followed by radium
- (2) Local removal of the breast if the tumor is very bulky, followed by radium
- (3) Never dissect the axilla
- (4) Radium by itself may be used (a) If the tumor is of moderate size and the diagnosis certain, (b) if the patient refuses operation

* Read before the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939

The possibility of different results being obtained by the American and the English surgeons from the employment of the Halsted operation, because of the existence of different ideas in the two countries of the technic of the operation, is suggested by a recent publication of Ogilvie.³ From his observations of the methods employed in several American surgical clinics, Ogilvie pointed out certain differences in American and English surgery and particularly emphasized the different technics employed in the radical operation for carcinoma of the breast by making the following statement

"I watched several dyed-in-the-wool Halstedians performing the radical amputation of the breast, and I felt that here the knife ideal, carried to its extreme, is the 'letter that killeth'. A dissection of the axilla with a knife is distressing to watch, the surgeon takes more than an hour to do part of the operation for which we should need ten minutes."

Ogilvie apparently believed that the sole purpose of the American Halstedian operation in the employment of the painstaking and time-consuming technic in the removal of the axillary contents was to secure the most perfect healing of the wound. The idea that the particular technic employed might increase the chance of complete removal of the disease was apparently not appreciated.

Besides the great difference in the technic employed by Mr. Ogilvie's "dyed-in-the-wool Halstedians" and those surgeons performing one-fourth of the operations in St. Thomas's Hospital, there also exist varying degrees of lesser differences in technic employed by surgeons performing the operations considered as standard in one country or even in one hospital. The radical operation for carcinoma of the breast is founded on a principle which makes it obligatory to assume that even a small difference in the technic would frequently produce a total difference in the result obtained. Any report, therefore, of the results obtained from the employment of any operative procedure for the cure of carcinoma of the breast, to be of value, must be based on experience in which there is in each individual case no doubt of the reality of the disease, a careful study of its demonstrable extent and the employment of a uniform operative technic. The purpose of this paper is to call attention to the fact that the value of operative treatment of the breast is now being questioned without sufficient analysis of the varying technics employed, and to report the results in a series of cases having the same operation and one which we believe conforms to the basic principles of the radical operation.

The radical operation for carcinoma of the breast may be defined as an operative procedure which, with due regard to operative mortality and permanent mutilation, removes in one mass all of the structures which are liable to immediate invasion by tumor. Operative mortality and permanent mutilations are important in determining the desirability of performing operations so extensive as to include a part of the chest wall or even a shoulder girdle, but differences of opinion or differences in appreciation of the importance of removal of structures liable to immediate invasion by the tumor are for the most part responsible for variations in the technic of the radical or Halsted operation as usually understood.

The importance of the phrase "one piece" in the definition of the radical operation for carcinoma of the breast cannot be overemphasized. In other words, the purpose of the operation is not the excision of the breast, pectoral muscle and axillary contents, but the extirpation of a single block of tissue so large as to include not only these structures, but all of the intervening and as much as possible of the surrounding tissues. The failure to appreciate this principle results, even where very extensive operations are performed, in piece-meal removal, or the separation of structures by tearing, thus leaving behind structures liable to be invaded by tumor.

The idea of wide *en bloc* excision of structures for the cure of carcinoma of the breast is founded on a conception of the mechanics of the regional spread of the primary tumor. This operative procedure assumes that at least in the structures which it is possible to extirpate in one mass, the tumor spreads from the original focus by continuous permeation in all directions, and that there is presumably a continuity of tumor between the primary growth and a circumference well outside the limits of visible tumor tissue. It is recognized that the rate of spread is different in different directions because of the ease of permeation in the direction of the course of many large lymph channels or the resistance of thick sheets of fascia not penetrated by lymphatic channels.

Regardless of the correctness of this theory, it, nevertheless, remains true that the radical operation for carcinoma of the breast as previously defined cannot be justified on any other theory of the mechanism of the spread of cancer originating in the mammary gland.

Mr. Charles Moore,⁴ in 1867, made the first clear-cut statement of the fundamental principles and purpose of the operation intended for the cure of carcinoma of the mammary gland. From observations of local recurrence after operations for cancer of the breast, Moore called attention to the frequency with which inadequate operation was performed and makes the following significant statements:

- (1) Recurrence of cancer of the breast is due to a local condition not belonging to structures out of continuity with the first tumor.
- (2) Centrifugal dispersion determines the recurrence of cancer.
- (3) Cancer of the breast requires the careful extirpation of the entire organ.
- (4) Besides the breast, unsound adjoining structures, especially the skin, should be removed in the same mass with the principal disease.

At the time these statements were made by Moore, the point at issue was whether secondary implantations of cancer of the breast were extensions from a single focus of origin or whether they represented other manifestations of general systemic disease (cancer diathesis). After it was no longer a question of cancer originating at a single focus, Handley arrived at almost exactly the same conclusion from a study of the relative importance of the two methods of extension of the malignant disease, *i e.*, by permeation or by embolism. It is interesting to note that there is no difference in the foundation for the

radical operation for carcinoma of the breast because of the change of concept from that at the time of Moore to that at the time of Handley. It is also worth while to point out that in view of the conditions under which surgery was performed during the time of Moore, his recommendations met all of the requirements of the previous definition for radical operation for carcinoma of the breast.

After the institution of aseptic methods, surgeons not only began the employment of new operative procedures, but were also able to extend the limits of operations long previously undertaken. Thus in operations for carcinoma of the breast, Volkmann, Gross, Hardenham, Kuster and others extended the operation to include the removal of the major pectoral muscle and axillary lymph nodes until the approximate limits of the present day operation were reached by Halsted⁶ and Willy Meyer, in 1894. The remarkable similarity in technic of these two surgeons and more particularly the phrases employed in the statement of fundamental principles involved even to the use of italics, is definite evidence of there being a common source of the ideas expressed in these two almost simultaneous publications. The larger experience of Halsted at the time of his publication, and particularly the continued interest on the part of Halsted for many years previous and subsequent to the appearance of his description justly entitle him to great credit for the development of the method which has until comparatively recently, been considered throughout the world as the standard treatment for the cure of cancer of the breast.

In a paper entitled "The Blood Clot in the Management of Dead Spaces in the Treatment of Wounds" Halsted,⁷ in 1890, refers to 13 instances in which operations were performed for carcinoma of the breast. The hospital numbers of these cases are recorded and in one instance, No. 381, the clinical history and the technic of the operation are as follows:

Wealthy Mason age 47 was admitted to the hospital March 20, 1890. About one year ago the patient noticed a lump no larger than a pea just external to the left nipple. The lump has gradually increased in size and is now about as large as a hen's egg. The axillary nodes are large enough to be felt.

Operation—March 21, 1890. The knife was introduced at a point from 3 to 5 cm. below the middle of the clavicle and drawn outwards on to and down the arm to a point a little below the insertion of the pectoralis major muscle. The knife was then reintroduced at the starting point and the tumor circumscribed by a skin incision which gave the diseased tissues at every point a wide berth—a berth of at least 5 cm. Each bleeding point as it presented itself was caught at once by an artery clamp. The tumor, the entire breast and all of the healthy tissues which had been circumscribed by the skin incision were removed in one piece from within outwards by cutting and tearing, from the ribs and from the fascia which covers the greater pectoral muscle. The triangular skin flap was dissected back to its base. The loose fascia which stretches from the lower border of the free edge of the pectoralis major muscle to the chest wall was torn through with the fingers; the major muscle was raised up from the chest wall and from the pectoralis minor muscle and cut away close to its trunk attachments and at about 5 cm. from its insertion into the humerus. The pectoralis minor muscle was divided transversely at about its middle and drawn upwards so as to completely expose the extreme apex of the axilla under the clavicle. The loose cellular tissue about the first portion of the axillary vein was dissected away with the fingers so as to clearly expose the axillary vein. Starting from this point the tissues were dissected clean from the axillary vessels and nerves down almost to the lower limit of the skin incision on the arm. Going back again to the apex of the axilla the axillary contents and with them all the cellular tissue and fat which covers the front and side of the exposed chest wall were dissected off clean from the ribs. The somewhat wedge-shaped contents of the axilla were thus removed in one piece from the apex to the base or floor of the axilla. The floor of the axilla had already been reflected in the triangular skin flap. The last cutting act of the operation therefore was to dissect the base of the wedge-shaped contents of the axilla from the reflected triangular flap of skin.

In 1894, Halsted⁶ published a paper containing a description of the technic of an operation which he states had been employed in 50 cases from January, 1889, to January, 1894. This technic he calls his complete operation, although it did not include removal of the pectoralis minor muscle.

This paper also contains brief abstracts of the clinical histories of the 50 cases, in each of which the hospital number and date of operation are given. In one instance, Case 1, Surgical Number 12, there is a description of the operator's technic in which, because of an abscess in the axilla, the breast and pectoral muscles and the axillary contents were removed at separate operations.

In 1898,⁷ Halsted stated that the operation he was employing was more radical than at the time of his first publication, because he was removing the supraclavicular lymph nodes. In 1907, he⁸ recommended extension of the operation in some cases to include the removal of a part of the chest wall. In 1921, in Doctor Halsted's⁹ last paper dealing with the operative treatment of cancer of the breast, he adds emphasis, by the use of italics, to the following statement concerning the radical operation:

"The initial account of the operation for cancer of the breast which bears my name lies buried in the second volume of the Reports of the Johns Hopkins Hospital under the title 'The Treatment of Wounds with Especial Reference to the Value of the Blood Clot in the Management of Dead Spaces'."

From these quotations it is clear that although all of those who were fortunate enough to be associated with Doctor Halsted while he was performing operations for the cure of carcinoma of the breast have an indelible picture of a Halstedian operation, others, because of the continuously changing technic and even conflicting statements in the published accounts, would probably obtain quite different ideas of the Halsted operation. For example, it is strange that the description of his operative technic in 1894 should have omitted the removal of the pectoralis minor muscle when the case records show he was occasionally removing this muscle as early as 1892.

It is also difficult to understand why Doctor Halsted should, in 1921, refer to the description of the breast operation in his paper of 1890 as the first account of his operation, when this operation so obviously violated the principles emphasized by him in 1894, and particularly because he, in 1894, apparently did not consider this case as having had his complete operation.

These discordant facts are not related for any other purpose than to call attention to the fact that there is no such thing as a radical operation for carcinoma of the breast as there is a Billroth II for carcinoma of the stomach, and that even Doctor Halsted was somewhat confused as to what constituted the operation bearing his own name.

During the present year, we have been able to determine the present condition of every patient admitted to the Vanderbilt University Hospital with carcinoma of the breast during the past 14 years. In most of the patients who were treated by radical operation, the same technic, both as regards amount of tissue removed and the manner of its removal, has been employed. One hundred forty-nine radical operations have been performed, with one death from wound infection. At present (1939), 72 cases, having had the

same operative technic, have been operated upon for periods longer than five years. In all these cases there is no doubt of the correctness of the diagnosis and all of the specimens removed have been studied carefully as to the type of tumor and particularly as to the extent of the disease. Ten other cases operated upon for more than five years are not included because of some doubt as to the diagnosis or the authors' not being sure of the exact operative technic employed.

The operative technic employed is briefly as follows:

(1) The first step in the operation is to make a circular mark on the chest wall to include the skin to be removed. The size of the circle varies according to the proximity of the tumor to the skin, but is only in exceptional instances small enough to permit closure of the wound without skin grafting. After the circle has been marked off, the actual incision employed has varied in configuration but was always outside the circular mark. Most frequently, this incision has been similar to that proposed by Rodman and modified by Greenough.

(2) The skin with very little subcutaneous tissue is raised from the entire axilla, deltoid region, and the chest wall from the medial aspect of the mammary gland to the opposite side of the sternum and slightly above the clavicle.

(3) The subcutaneous tissue and fascia are then incised from the anterior margin of the latissimus dorsi muscle, around the axilla, along the cephalic vein, and the inferior margin of the clavicle.

(4) The above incision is continued in depth until the insertions of the pectoral muscles are divided and the clavicular portion of the pectoralis major muscle is divided along the inferior margin of the clavicle.

(5) The axillary contents are separated from the vessels and nerves by sharp knife division in a plane across the axilla at the inferior border of the axillary vein. All branches of the vessels and nerves are divided at the level of the inferior margin of the vein. No attempt is made to dissect structures at a higher level. The incision is extended through the axilla to its posterior wall and thence to the chest wall.

(6) The lateral skin flap is then elevated to a line lateral to the anterior margin of the latissimus dorsi muscle, the costal margin and the xiphoid process.

(7) The subcutaneous tissue and fascia are then divided down to the chest wall, beginning at the posterior axilla, along the anterior margin of the latissimus, across to the xiphoid process, and finally to the sternoclavicular joint.

(8) *This completes the division of the margins of the block of tissue to be excised.*

(9) The entire mass is then cut away from the chest wall with the least amount of traction and tearing.

In patients subjected to radical operations we believe the extent of the disease as determined at operation or from subsequent study of the gross specimen is far more important in prognosis than any classification of tumors according to "grades" of malignancy. This series of patients is, therefore, divided into three groups:

Group I No demonstrable cancer outside the mammary gland at operation or from subsequent gross and microscopic examination of the tissues removed

Group II No cancer observed during the course of operation but cancer later demonstrated in inferior axillary lymph nodes by microscopic study

Group III Cancerous nodes seen in the axilla or near the chest wall at the time of operation

In all cases placed in Group III the operative note contained a specific statement that cancerous tissue was seen during the operation. In most of the cases included in Group II the operative note made a specific statement that no enlarged lymph nodes were seen. A few instances in which the operative note contained no statement bearing on this point were placed in Group II. Group I contains the cases in which microscopic examination of numerous axillary lymph nodes showed no tumor.

The results obtained from the employment of the operative technic previously described in 72 cases, all of whom have been operated upon for more than five years, are shown in Tables I, II, and III.

TABLE I
PATHOLOGIC CLASSIFICATION

	Num- ber of Cases	Living and Well	Living with Recu- rence	Dead Recu- rence	Dead of Other Causes	Per Cent Cured 5 Years or Longer	Per Cent Now Living and Well
Group I	12	11	0	1	0	91.6	91.6
Group II	29	10	2	17	0	34.5	34.5
Group III	31	4	1	25	1	16.1	12.9
Total	72	25	3	43	1	36.1	34.7

From Table I it appears that the operative procedure employed in this series of cases can be expected to cure 90 per cent of cases of cancer of the breast if there is no demonstrable tumor outside the mammary gland, but it is also true that there is no evidence contrary to the conclusion that equally good results in these particular cases could not have been obtained by much more conservative means. In fact one of the patients not included in this report is well 11 years after a simple mastectomy, because a severe infection prevented radical removal.

TABLE II
Interstitial
Radiation
(Keynes)

Pathologic Classification	Interstitial Radiation (Keynes)		Radical Mastectomy (Vanderbilt University Hospital)		
	Number of Cases	5-Year Survival Rate	Number of Cases	Living and Well 5 Years	5-Year Survival Rate
Carcinoma without axillary metastases	75	71.4%	12	11	91.6%
Carcinoma with axillary metastases	66	29.3%	60	16	26.7%

In spite of the fact that only one-third of all the patients with metastases to the lymph nodes nearest the mammary gland were apparently cured by operative treatment, the results obtained in this group are after all the principal support of the value of radical operative treatment. These patients could not have been cured of the disease by a simple mastectomy and all of my experience has been contrary to the view that as good survival periods could have been obtained by the employment only of conservative operations.

TABLE III

Number of Years Followed	Groups			Total Number of Patients	Number Now Living and Well	Per Cent Now Living and Well
	I	II	III			
13	0	5	4	9	3	33.3
12	0	2	1	12	4	33.3
11	1	2	2	17	6	29.4
10	2	1	3	23	9	39.1
9	2	3	4	32	12	37.5
8	1	2	3	38	13	34.2
7	0	6	6	50	16	32.0
6	4	3	3	60	23	38.3
5	2	5	5	72	25	34.7

The distressingly poor results obtained after operations in which cancerous tissue appears in the operative wound, particularly because this group is largest in number, although constituting most of the evidence against the efficacy of the operative treatment, is the strongest evidence for the assertion that, if operative treatment is to be undertaken, it should conform, in greatest degree possible with the fundamental principles on which this treatment is based, and emphasizes the apparent necessity of any curative operation having to extend well outside the limits of visible tumor. If, however, this large group, found almost hopeless at operation, is added to the one-third of all breast cancers found hopeless before operation, it brings into bold relief the smallness of the accomplishment of the radical operative treatment of cancer of the breast, and the importance of determining the relative usefulness not only of each of the widely varying operative technics, but also of other methods more recently discovered.

REFERENCES

- ¹ Mitchner, Philip H, Bailey, G. N., and Price, A. K. St. Thomas's Hosp. Rep., 2, 2nd Series, 192, 1937.
- ² Keynes, Geoffrey. ANNALS OF SURGERY, 106, 619, 1937.
- ³ Ogilvie, W. H. Guy's Hosp. Gaz., 53, No. 1326, 172, May 20, 1939.
- ⁴ Moore, Charles H. Medico-Chirurg. Trans., 40, 245, 1867.
- ⁵ Halsted, W. S. Johns Hopkins Hosp. Rep., 2, 255, 1890-1891, Maryland Med. Jour., 24, 529, 1891.
- ⁶ Halsted, W. S. Johns Hopkins Hosp. Rep., 4, 297, 1894-1895, ANNALS OF SURGERY, 20, 497, 1894.
- ⁷ Halsted, W. S. ANNALS OF SURGERY, 28, 557, 1898.
- ⁸ Halsted, W. S. ANNALS OF SURGERY, 46, 1, 1907.
- ⁹ Halsted, W. S. Johns Hopkins Hosp. Bull., Baltimore, 32, 309, 1921.

DISCUSSION —DR ROY D McCLURE (Detroit, Mich) There are a few of us here to-day (James Mitchell, George Heuer, Willis Gatch and myself [Doctor Brooks himself was there for a time]) who spent many years with Doctor Halsted, serving as Assistant Residents and Residents. One thing we can say is that many who to-day claim to be performing the Halsted breast amputation are not carrying out the Halsted procedure as he himself performed it. He took perhaps three hours or more, and few to-day would think of devoting three hours to the operation. Halsted may have been a slow operator, but he was moving every minute of the time, and I can assure you that the assistants had to be alertly on their toes.

My main criticism to-day is that some who claim to perform the Halsted amputation take so little skin that they are able to close the defect without a skin graft. When I was Halsted's Resident, we removed a liberal margin of the skin and never worried about how large a graft was to be used. All the Residents of that time acquired great skill in removing large sheets of intact skin from the thigh. To-day, with the instruments available, almost anyone can easily take such skin grafts, so that now perhaps surgeons will not be so loath to undertake large areas of skin removal. Doctor Halsted spent much time on the axilla, and it was time well spent. The vessels and nerves were clean when he finished with them. There were no nodes and no node-bearing tissue left. Even before this Society I have heard described as the Halsted operation a procedure which was not the Halsted operation as I learned it directly from him. Those who are familiar with his work know that his patients did not suffer any shock, and I believe his results have never been surpassed even though Sampson Handley's work in the lymphatics and the manner of spread of cancer of the breast may be questioned. Halsted did his radical operation long before Sampson Handley's lymphatic work was brought to our attention, I believe it was conceived from his study of actual recurrence areas and actual metastatic areas. It was based, then, on an actual study of such patients and not on a theoretic study of possible line of spread through the lymphatics.

Last year, Dr Arthur McGraw and I reported briefly our results before the Society of Neoplastic Diseases. Our results showed that half our own cases had received adequate irradiation by deep roentgenotherapy. This treatment had no effect on the end-results. I hope that Doctor Brooks' communication will not turn you too much from the radical type of operation.

DR CHARLES LUND (Boston, Mass) First, I must tell you what an honor and pleasure it is to be asked to come here to this meeting and to be allowed to join in the discussion. We have a long series of studies of cancer of the breast, started by J Collins Warren and continued by R B Greenough and others in Boston. We would agree, 100 per cent, with the conclusions of the two papers presented, and we believe fully in radical operation for operable cases. I am not going to enumerate all our ideas. First, there should be elimination from surgical treatment of inoperable cases, cases where there is fixation to the chest wall, or with metastases beyond the axilla. All cases get a roentgenologic examination of the chest, spine, pelvis and skull to find if there are evident metastases in the lungs or bones. If there is any great edema of the breast or skin metastases, the cases are also inoperable. We get about the same results that Doctor Brooks reports. We have some statistics which I think should be interesting to anybody considering the subject of simple mastectomy versus radical mastectomy as a comparison of pre-operative estimations of malignancy of the nodes, with what was found.

If you take 100 cases in which a good surgeon says, after examination, that the axillary nodes are positive and then look at the pathologic findings

following a radical removal, you will find, nine times out of ten, that he was right. Occasionally, there are enlarged nodes that are not positive. But if you take his estimation, when he says the nodes are not palpable and are not involved, we find he is wrong 40 per cent of the time. If such nodes are not removed, we do not believe any postoperative roentgenotherapy will control them for any length of time. We base this on hundreds of cases studied at the Massachusetts General and the Collis B. Huntington Memorial Hospitals.

As to irradiation of the ovaries in cancer of the breast, we had a similar case some years ago in which Dr. G. W. Taylor reported the findings. With us, this procedure is apparently dying out. We are not getting the results we hoped for and are giving it up. We are not using postoperative irradiation as Doctor Trout does. We are using more than we were a few years ago. We formerly believed it was unimportant in all cases and we gave it only if there were recurrences. We have changed that to some extent. The pathologist now gives us a report of carcinoma of the breast of such and such a grade, with so many nodes involved, and if there is no involvement of the axillary nodes or only one or two are involved, we give no postoperative treatment unless recurrence takes place. However, if many, or most, of the nodes are involved or if the tumor is highly malignant, we do give postoperative treatment at once without waiting for metastases to become evident.

DR. ROLLIN A. DANIEL, JR. (Nashville, Tenn.) I would like to present, very briefly, some additional data concerning the group of patients which Doctor Brooks presented. The 72 cases reviewed are included in a total of 120 patients seen at the Vanderbilt University Hospital, during that period of time. Since only 12 of these patients fall into Group I, I think it is fair to say that only 10 per cent of the patients with carcinoma of the breast who presented themselves for treatment could have been cured by simple mastectomy, or by any operative procedure less radical than the operation described by Doctor Brooks.

Table I reviews briefly the roentgenotherapy employed in the 72 cases reviewed in the text of Doctor Brooks' paper. Roentgenotherapy was not administered preoperatively in any case in this group, and this table does not consider patients who were treated after recurrences were found. In all instances, from one to four large doses of irradiation were administered, which were measured on a basis of skin-erythema dosage, and in no case was carefully measured, protracted irradiation, as it is used now, employed.

TABLE I
PERCENTAGE OF CASES IRRADIATED AND RESULTS

	Total Number of Cases	Number Living and Well	Per Cent Living and Well	Groups	Number of Cases	Number Living and Well	Per Cent Living and Well
Given roentgeno- therapy	19	6	31.6	I	3	2	66.6
				II	7	3	42.8
				III	9	1	11.1
Not given roent- genotherapy	53	19	35.8	I	10	10	100.0
				II	21	6	28.5
				III	22	3	13.6

Table II is based on data obtained from patients' histories. The similarity in the last two groups is striking. It is also interesting that the number of

patients considered hopelessly far advanced, when first seen, is larger than the group of patients who have remained well for periods of time exceeding five years

TABLE II

AVI RAGE DURATION OF LIFE AFTER TUMOR WAS FIRST NOTICED BY PATIENT

26 patients cured 5 years or more after radical mastectomy 9 years, 1 month (all living now but one)
41 patients having recurrence within 5 years after radical mastectomy 3 years, 5 months
38 patients considered inoperable when first seen 3 years, 3½ months

DR WALLER O BULLOCK (Lexington, Ky) I would like to discuss one point in Doctor Trout's paper and say that, in irradiation of the pelvic structures, particularly the ovaries, to prevent involvement of the opposite breast, it would seem that simple mastectomy of the opposite breast in a young woman is much less mutilating to her personality than a procedure which suppresses menstruation

DR JAMES F MITCHELL (Washington, D C) I would like to add a word to what Doctor McClure has said I worked with Doctor Halsted for ten years, from 1893 to 1903, and during that time he was developing his breast operation, adding a little more each year, and his operation, as Doctor McClure said, was long and tedious Bloodgood carried the operation further, and after Halsted had finished, Bloodgood would go on I think Follis made the best comment He said two men ought to perform every breast operation, and the best thing was that they should be bitter enemies The first man should perform the operation and leave the second man to close the defect There would be plenty of exposure for him to make We are all coming back to Halsted's teaching in the matter of breast operations and the matter of silk I was brought up on silk and have always used it, and to see men come back to it is a great tribute to Halsted's wisdom We, who had the pleasure of working with him, knew his meticulous care in operating and in all the things for which the whole country owes him a debt of gratitude

I feel that Doctor Trout's ideas as to the treatment of carcinoma of the breast represent the most thorough and most rational scheme of to-day

DR L WALLACE FRANK (Louisville, Ky) There is one thing which was mentioned by Doctor Mitchell that I wish to call to your attention, and that is the skin incision Since 1919, I have performed radical mastectomy for cancer of the breast in about 190 cases and in none have I found it necessary to do a skin graft I might also add that in this number I can recall only three patients who developed local skin recurrence The frequency of local skin recurrence and of axillary recurrence is in a measure an index of the thoroughness of the operative technic We see very few recurrences in the nodes in the axilla We do have recurrences in the nodes above the clavicle What we see most frequently are pleural, lung, liver, and bone metastases

I do not think that we cure cancer of the breast, we only arrest the disease I have seen too many patients die 8, 10, 12 and even 15 years after operation due to a recurrence, or, rather, I should say recrudescence of their disease Many of these patients died as a result of bone metastases It goes without saying that when there is no recurrence in the operative area and the patient dies some years later of distant metastases, that these metastases had occurred previous to operation Why these cancerous deposits should be inactive for so long without giving any signs or symptoms, no one can say When

we find out what the stimulus is that starts these dormant cancer cells to again become active we will have gone a long way toward finding the cause of cancer

DR HUGH H. TROUT (Roanoke, Va.) In my original paper many other points will be covered which are not contained in the paper read here

There is one rather serious and usually unrecognized danger of irradiation. If one believes that irradiation has any virtue, one is apt to become careless as regards the extent of thoroughness of the operative procedure. I say this in spite of the fact that many of us here were trained either directly or indirectly by Doctor Halsted and are firm believers in his teachings.

Concerning the inoperable cases. We have had 11 such cases that we considered absolutely inoperable, and treated them with irradiation. After a few months of irradiation, six of these cases became what we considered a fair operable risk. Three of these six cases have remained free from carcinoma over five years following operations.

Nodes in the axilla present an interesting study. For example, one node in the axilla apparently offers a better prognosis than many small, shot-like nodes. Doctor Ewing is under the impression that one large node demonstrates that malignancy has been effectively plugged, and that shot-like nodes suggest that the malignancy has percolated through. We have had five cases in which extensive search of the axilla showed no signs of nodes at the time of operation or in the specimen examined after operation, yet all five of these cases died of metastases. This experience suggests that, in a certain number of cases, extension occurred through the blood stream and not through the lymphatics.

We have irradiated the ovaries in very few young women, certainly not enough to have any definite views on this subject.

In reply to Doctor Bullock's question, I will state that amputation of the remaining breast would only be part of the picture, for by irradiation of the ovaries is not only hoped that the remaining breast may be spared but, also, that the development of metastases may be prevented elsewhere in the body.

DR BARNEY BROOKS (Nashville, Tenn., in closing) I would like to add emphasis to my feeling that the advisability of treatment of carcinoma of the breast solely by operation is now being justly questioned. There are a great many thoughtful surgeons who are definitely of the opinion that this operation will not be very much longer employed. This method of treatment should not be condemned on the basis of poor results obtained by the employment of any operative technic which does not conform to the principle on which the radical operation is founded. There is much need at the present time for a very careful study of the whole question of treatment for carcinoma of the mammary gland.

THE RÔLE OF IRRADIATION IN THE TREATMENT OF CARCINOMA OF THE BREAST*

HUGH H. TROUT, M.D.

ROANOKE, VA

I CERTAINLY hope no one will receive the impression—no matter what I might say concerning irradiation—that I consider that there is, at present, any substitute for the radical operation in the treatment of carcinoma of the breast. Of course, much harm can be done by an improperly executed operation in this disease. Also, even more harm can be done when properly executed operations are performed in badly selected cases. In neither of these instances should surgery be condemned. The same rule of fairness should, I think, be applied to the application of irradiation in association with surgery in the treatment of carcinoma of the breast. The great difference is, however, that surgery, after many years of study, is now more or less standardized in its application to the treatment of this disease. Such is, certainly, not as yet the situation relative to irradiation. Assuredly, this lack of standardization adds to the confusion of determining as to what is the correct procedure relative to the application of irradiation to surgery in the treatment of carcinoma of the breast. I am even more firmly convinced that improper irradiation can, and frequently does, do more harm than even improperly applied or badly executed surgery, for the boundaries of the chest wall and axilla limit the field in which surgical mistakes can be made, while no one knows the full extent of damage done by improperly applied irradiation.

There are many advocates of the irradiation treatment in this disease, who believe the time is near when roentgenotherapy and radium will take the place of surgery in the treatment of carcinoma of the breast, somewhat as they have done in the treatment of carcinoma of the cervix. I personally do not share this belief, for I feel the breast, muscles, nodes, *etc.*, can be more thoroughly, more easily, and more safely removed without contamination of the operative field by the spreading of stray cancer cells and, certainly, with a very much lower mortality than the uterus, nodes, *etc.*, can be completely removed from the pelvis.

The views I am about to express are my own personal opinions which are based on (1) An interested and extended study of the literature, (2) my contacts with surgical and radiologic friends (both those believing in the efficacy of irradiation as well as those holding "no brief for any of it"), and (3) an intimate and close study of over 600 cases of carcinoma of the breast observed for over a quarter of a century. Lastly, and most certainly, my opinions are not based on any facts, for facts are unknown in association with irradiation. However, I cannot help but believe that physical agents, which

* Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

have so revolutionized and improved the treatment of cancer elsewhere in the human body, can and should be of aid in extending the effectiveness of the surgical removal of carcinoma of the breast, provided such agents can be employed without doing damage to uninvolved tissues

The effects of radium and roentgenotherapy will have to be considered both from their remote as well as their local application

It has been most interesting to me to watch the changing attitude of the medical profession relative to whether preoperative irradiation, postoperative irradiation, radium or combination of all three should be employed. The only actual *fact* that I know definitely concerning irradiation is that the type, the time, the frequency, and the response require a careful study of each individual case, also, that such a study should be made with the close and the frequent cooperation of a group consisting of a surgeon, a radiologist, a pathologist, and, whenever possible, the family physician. Also, in our part of the country, this group should include the hospital managers, for it is unreasonable to expect cooperation from the patient and from the family unless they know, fairly definitely, what the combined cost of their experience with this group is to be. I am confident we have failed in the past to obtain the proper cooperation from the patient and from the family because we had not given them complete information concerning their financial obligations. This is particularly true with families who are too foolish, and too proud, to admit their financial situation is not as good as the community believes it to be.

Before considering any of the combinations of irradiation employed with surgery, I am firm in my opinion that any form or frequency of irradiation that produces necrosis or an extensive destruction of the skin is harmful. Also, if the irradiation is so intense as to do damage to the skin, it is reasonable to presume malignant invasion will take place more frequently and more rapidly than if the protective influences of surrounding tissues had not been injured by roentgenotherapy. In other words, if the irradiation is too intense, recurrences are apt to occur, and when they do appear the skin will be in no condition to receive further irradiation.

Furthermore, I am certain, a trial dose of irradiation, whenever possible, should be employed to obtain some idea of the skin response of that individual patient to irradiation. I will not discuss further the dosage of irradiation, for this is not the function of a surgeon.

Of course, the dosage, the character and the type of machine, *etc.*, have all changed from year to year, which, necessarily, only adds to the confusion in trying to make a proper estimate of relative values with the various methods. In addition, I am not competent to discuss that which is the distinct function of the radiologist. However, we have made some general observations concerning the patient's reaction to irradiation that are interesting.

For example, we feel that young women will be found, as a general rule, to have that type of malignancy which is more radiosensitive than is found in the older group. In other words, histologic Groups 3 and 4 are more

frequently found in young women than Groups 1 and 2. Also, the clinical index is much higher in the younger group. Theoretically, the addition of irradiation to surgery should improve the prognosis in this group of cases even more than it does in the older women. We feel this has been true in our series, but, of course, have no way of knowing definitely concerning the accuracy of this observation. Also, better results are obtained in the younger group by giving irradiation at shorter intervals than seems advisable or necessary with older women. Perhaps this is due to the fact that in an actively growing malignancy, cell division takes place more rapidly, and as is well known, irradiation is more effective on the immature cells. This is but one of the many reasons illustrating the necessity of group observation in the proper treatment of carcinoma of the breast. I feel quite certain a study of the life cycle of the cancer cell is of much aid in determining the type, the dosage and the frequency of irradiation necessary to obtain the best results in any malignancy.

In our series, there have been found more inoperable cases of carcinoma of the breast in young women than have been found in women past the menopause. This is probably due to the fact that in such cases the growth of the malignancy is more rapid than it is in the older group.

It is our general plan to: First, employ preoperative irradiation, second, at the time of operation to place many small tubes of radium around the entire operative field and under the skin, and third, to follow this with post-operative irradiation. In addition to these three forms of application of irradiation we have in quite a few cases, employed irradiation of the pelvis.

Perhaps it would be of profit for us to discuss some of the indications and some of the contraindications for the employment of preoperative irradiation in different types of cases. It is, however, our general aim to employ all three types of irradiation in every case possible.

We do not feel that preoperative irradiation is as effectively administered in our organization as we would like it to be. We do not seem to be able to control our patients as well as some other organizations with which I am somewhat familiar. With us, our patients will not permit us to take the two to three weeks' preoperative preparation that is apparently required to obtain the best results. Also, some of them fail to return at the appointed time—when the mass begins to become smaller—but delay continuation of their treatment until the malignancy has had time to extend beyond the reach of surgery and irradiation. For this reason, we have been employing in some cases, doses of roentgenotherapy that require only 48 hours of preoperative irradiation, but, of course, we have no method of estimating the effectiveness of this method. However, we hope, and we believe, it is reasonable to presume that cancer cells, after exposure to such irradiation, are made less active and therefore, any stray cancer tissue remaining in the field of operation might not be so apt to attach itself to surrounding tissue.

Preoperative irradiation, we feel, is especially indicated in the following cases: (1) Those patients having palpable nodes in the axilla. It is interest-

ing to recall that where one large single malignant node is found in the axilla, the prognosis as regards metastases is far better than in those cases having small, shot-like nodes. Many pathologists feel one large malignant node is a demonstration of the effectiveness of that particular node to block further spread of the malignancy, whereas the presence of numerous small, shot-like malignant nodes is an expression of the inability of the lymphatics to successfully limit the extension of the malignancy.

Of course, we have all seen cases of carcinoma of the breast in which a careful microscopic study of the nodes removed from the axilla showed no signs of malignancy and yet these patients soon developed metastases in distant parts. In such cases the cancer cells are probably carried to the site of the metastases by the blood stream and not by the lymphatic system.

(2) Those cases in which the malignancy is fixed either to the skin or to the underlying muscle.

(3) A limited number of cases, who, due to senility, cardiac or some such general condition, are not able to take a prolonged anesthesia with sufficient safety to justify the risk, can be brought, in a few instances, to the stage in which the breast can be removed under a local anesthetic, and with both physical and mental comfort to the patient.

(4) Those cases of very rapidly growing malignancy, especially if associated with infection.

(5) Those cases associated with pregnancy.

(6) A few apparently inoperable cases can be so improved by preoperative irradiation that a radical operation can be performed with a fair prospect of prolonging life.

(7) In those cases where there has been an implant of the carcinoma in the tract of an aspiration biopsy needle. We have had two such cases, and in both of them the biopsy diagnosis was that no malignancy was found, yet carcinoma developed right under the skin at the site of the needle puncture. We have never considered the punch or aspiration biopsy to be either a safe or an accurate method of making a diagnosis of carcinoma of the breast.

Radium at the Time of Operation—We use 15 to 20 small needles (3 to 5 mg. each) of radium implanted under the skin at the time of operation in different localities, giving especial attention to the axilla and the territory drained by the internal mammary lymphatics, for these are the two most frequent localities of local recurrences. Strings are attached to these needles, and they are gradually withdrawn at the lower end of the incision. The pull on the strings is started about 12 hours after completion of the operation, and they are then withdrawn about one inch each hour. We formerly employed larger doses of radium in capsules, but obtained some skin necrosis as well as two cases of necrosis of the costal cartilage which required removal of a section of the cartilage. We feel the small needles are a distinct improvement. Radium is not employed in those cases requiring skin grafts. We are impressed with the fact that, in recent years, we have been employing skin

grafts more frequently as our incisions are now being made at a far wider distance from the growth than they were a few years previously

The field of operation is also flushed out with several quarts of saline solution, as hot as can be tolerated by the hand. Of course, it is well known that even a relative low degree of heat will kill cancer cells, and it is possible the flushing process might also wash out some detached malignant cells

Geoffrey Keynes reported a series of cases in which he performed a simple mastectomy with absolutely no dissection of the axilla, but implanted radium needles to take care of the involved lymphatics. He stated that there were no swollen arms following the implantation of radium in the axilla. We have never seen any postoperative swollen arms except in those cases that have had some infection in the axilla. Halsted and his coworkers demonstrated many years ago that an infection prevents the regeneration of lymph canals

Keynes also reported a few cases of brachial nerve neuritis. In addition to these complications, his results did not, in my opinion, justify the continuation of this practice

Reports, such as Keynes, help create a distinct, and frequently unrecognized, danger to the employment of irradiation in association with surgery—the surgeon who believes too strongly in the efficacy of irradiation might allow himself to become somewhat careless in the thoroughness of his dissection

In my opinion, whenever possible, the radical operation should always be performed. Preference should not be given to less radical methods purely because they might perhaps be attended by a lower operative mortality. When dealing with cancer, the value of any method should not be estimated entirely by the operative mortality rate, but by the effectiveness with which recurrences and metastases are prevented

Keynes, later, reported a series of cases treated by interstitial implantation of radium needles. In a number of these cases he removed the breast after about six months, following this type of irradiation. Examination of these specimens of amputated breasts showed no signs of carcinoma in over 50 per cent of the cases. The microscopic picture suggested an almost complete fibrous replacement of the malignancy. In a few cases carcinomatous cells encapsulated by fibrous tissue were found. Ewing reports a somewhat similar microscopic picture to exist in the breast following preoperative external irradiation

McKittick tried Keynes' method in a series of cases, and concluded that interstitial irradiation was not desirable for the following reasons: Pain in the breast, fixation of the pectoral ridge, and late deformity. He also considered that the final results did not justify the abandonment of the radical operation

We give postoperative irradiation to all cases and try to start the same about ten days after the operation. This method also applies to those cases having skin grafts. Apparently irradiation kills the skin graft if applied in

less than ten days of the time of the placing of the graft over the field of operation

In the period extending from 1909 to 1920, there were 152 cases in which only the radical operation was performed. In this group, there were ten local recurrences, and the percentage of three-year (or over) "cures" was 22 per cent. In the period extending from 1920 to 1924, there were 80 cases in which radium under the skin was added to the radical operation. In this group there were four local recurrences, and the percentage of three-year (or over) "cures" was 30 per cent.

In the period extending from 1924 to 1939, there were 211 cases in which radium and postoperative roentgenotherapy were added to the radical operation. In this group there were eight local recurrences, and the percentage of three-year (or over) "cures" was 55 per cent.

In the period extending from 1924 to 1939, there were 126 cases in which pre- and postoperative irradiation, as well as radium, was added to the radical operation. In this group there were no local recurrences, and the percentage of three-year (or over) "cures" was 55 per cent.

From a review of these figures, one might conclude that the improvement in the percentage of three-year (or over) "cures" was due to the addition of irradiation to the radical operation, but I feel quite confident that this improvement is due to education more than any other one factor. Of course, it is impossible to accurately state how much, if any, irradiation has had to do with this improvement. It is, however, reasonable to presume if its use had decreased the percentage of local recurrences it might have prevented some of the metastases which may have occurred. However, the reason I state that I think education has had more to do with our good results than any other one factor is that we are certainly seeing our cases of carcinoma of the breast much earlier than we formerly did.

It is the general practice throughout the country to treat local recurrences with irradiation after such have occurred, but I am sure it is better, if possible, to prevent such local recurrences by the addition of irradiation to radical surgery, in spite of the fact that absence of local recurrences does not apparently improve the percentage of "cures."

There have been 11 cases in which it was impossible to remove all of the malignancy from the chest wall. Radium needles were inserted in the remaining malignancy and intensive postoperative irradiation administered. All of these cases soon died from metastases, but in nine of the 11, the malignancy was removed from the chest wall by the addition of irradiation before the death of the patient.

We have had five cases from which we have removed only the breast, believing, at the time of operation, that no malignancy was present. In all five cases we considered the condition to be a benign tumor associated with a generalized cystic mastitis, and, therefore, removed the entire breast. In none of these cases did the frozen sections show carcinoma at the time of operation. Malignancy was discovered several weeks following operation,

following an extended study of the permanent sections, and then irradiation was administered. Fortunately, there has been no return of the malignancy in any of these five cases. Probably the malignancy was so early in all five of these cases that all that was necessary was the simple amputation. However, the delayed postoperative irradiation did no harm to the patient either mentally or physically, and might have done some good.

We were not able to obtain a single autopsy in any of the cases that died of metastases, and, therefore, do not have any definite knowledge concerning the presence of residual malignancy in the axilla. Nor can we be absolutely positive that there were no local recurrences. All we can report is that we examined all these cases some months, and often years, after operation, and found no local recurrences in this group. Then, also, we have reports in every case from either the family physician, or some member of the family, to the effect that no local recurrences occurred either in those cases still living or those cases that died from metastases or from other causes. We try to examine every patient once every month, for a six-month period, and then every three months for five years.

I feel we can conclude from this experience that proper irradiation of the chest wall aids radical surgery only in the prevention of local recurrences and not in the "cures." In other words, it is the metastases that kill and not the local recurrence.

We have had some very interesting experiences in the employment of roentgenotherapy for the relief of pain associated with metastases. In the majority of cases the pain has been relieved, but, as far as we can ascertain, there has been no prolongation of life—only the alleviation of pain and some mental comfort, both of which fully justify the employment of roentgenotherapy in such cases.

In 1931, Dr. C. H. Peterson treated a case that had extensive metastatic involvement of the bony pelvis, associated with an inoperable and ulcerating carcinoma of the breast. After several weeks of irradiation of the pelvis, the pain not only subsided in the pelvis, but the malignant ulceration of the breast showed such marked improvement that the skin healed over the ulcer and the breast lesion ceased its foul-smelling discharge. Of course, this patient went on to her death, apparently as if there had been no improvement in the breast condition. This experience made us have a natural curiosity as to what possible association there could be between the improvement of the breast condition and the irradiation of the pelvis. About the same time we were speculating concerning such a relationship the radiologists began to advocate the irradiation of the pelvis, and many advanced the theory that the beneficial results were due to the action of the roentgen rays upon the ovarian hormones.

There have been many theories advanced to explain what does actually happen when the ovaries and their hormones are exposed to the influence of the roentgen rays. However, I feel quite confident no one has any definite knowledge regarding this relationship. Clinical observations do not always

seem to coincide with the various theories advanced. For example, if irradiation decreases the production of carcinogenic hormones by the production of an artificial menopause, why is it that carcinoma of the breast is more frequent during those years following a natural menopause? This apparent conflict naturally raises the question as to whether the ovaries should be irradiated in those cases who are below the age of the normal menopause. However, some of the best clinical results reported have been in young women. For example, those cases of lung metastases which have disappeared after irradiation of the ovaries have been in young women in the majority of cases. In our limited experience the most marked benefit we have seen in the breast condition has been in the young women with rapidly growing carcinoma of the breast who have had preoperative irradiation of the local condition as well as the ovaries.

Sufficient experimental work has been undertaken to serve as a warning against the continued indiscriminate employment of estrogenic hormones for the relief of pain and swelling in the breast associated with the menses. In mice, carcinoma can, apparently, be produced by the repeated injections of such hormones. Allaben and Owen report a case illustrating the unwise use of estrogenic substance during the menopause. Certainly, there is neither the clinical experience nor the theoretic basis to justify the irradiation of either the breast or the ovaries in a patient suffering with such symptoms, in expectation of relieving the pain or preventing the future development of malignancy.

It might be that some of the remarkable results obtained in the treatment of carcinoma of the cervix by radium and roentgenotherapy are due to the effects of irradiation on the ovaries as well as due to the local application of radium.

There have been several studies of the incidence of carcinoma of the breast occurring in patients who have had their ovaries removed by operation, in comparison with a normal group of the same age. These series have been too small to be of much practical value. In over one-half of our cases of carcinoma of the breast occurring in women over 50 years of age, menstruation was still present.

Some radiologists advocate the irradiation of the ovaries in all cases of delayed menopause as a prophylaxis against the future development of malignancy, not only of the uterus, but also of the breast. Certainly, the production of an artificial menopause in young women protects the remaining breast from future lactations, and thereby decreases the chances of malignant involvement of that gland.

One naturally hesitates to inflict all the symptoms of an artificial menopause on a young woman. However, cancer is always a very serious condition, and nothing should be left undone, provided what is being done is not harmful.

In this group of young women below the menopause, we feel that irradiation of the ovaries is especially indicated. (1) If the tumor is growing rapidly. (2) If there is an associated infection. (3) If pregnancy is present. In such

cases an abortion should also be performed in addition to the irradiation, provided the pregnancy is under five or six months' duration. If malignancy of the breast develops during the last three or four months of pregnancy nothing seems to be of any benefit. (4) If the tumor is fixed to the skin or underlying structures. In other words, irradiation of the ovaries should be employed in those cases in which there exists any indication that the malignancy has extended or is going to extend beyond the chest wall. (5) As a routine practice in cases of recurrences. (6) In cases of inoperable carcinoma of the breast.

These young cases do not differ from any other instances in a surgical experience, namely, that each one has to be studied and treated as an individual case, and no general rule should be followed.

If the patient with carcinoma of the breast has passed the menopause, however, irradiation of the ovaries produces no bad symptoms, and should be administered in all cases, especially as there have been a few such cases reported where such treatment has been of apparent benefit.

I believe that all we can say at the present about the irradiation of the ovaries in association with the treatment of carcinoma of the breast, is that we do not have sufficient experience to properly evaluate the procedure as regards its true clinical value, nor am I familiar with any theory concerning its method of operation that has been advanced that fits all of the clinical results which have been reported by numerous observers. In other words, we do not now have either the clinical experience or a satisfactory theory which would justify the formulation of any definite rules governing the application of this powerful, and probably dangerous, agent. All of which means that, right at present, irradiation of the ovaries, especially in young women, should be employed only after a careful study of each individual patient, and such a study should be made by a group of doctors competent to evaluate this method, which has not as yet been standardized.

In conclusion, I feel quite confident that properly applied irradiation is of distinct aid to radical and carefully executed surgery in the prevention of recurrences, and, perhaps, of metastases in the treatment of carcinoma of the breast. However, irradiation possesses no replacement value for surgery, especially if the surgery is performed with meticulous care.

THE SCALENUS ANTICUS SYNDROME WITH AND WITHOUT CERVICAL RIB*

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THE increasing frequency of recognition of symptoms due to compression of the brachial plexus and subclavian artery by the scalenus anticus muscle indicates that this condition is one of the most common causes of pain and unexplained vascular changes in the upper extremities. Attention was first drawn to the scalenus anticus muscle as a possible factor in the production of symptoms arising from cervical ribs by Murphy,¹ in 1906. The actual rôle played by this muscle, however, was not clearly understood until Adson and Coffey² demonstrated that section of the muscle was all that was necessary, except in rare instances, to relieve symptoms attributed to cervical rib. That the symptoms of cervical rib may exist in absence of roentgenologic evidence of the latter has been a matter of common clinical experience recorded by many observers. Bramwell,³ in 1903, attributed the symptoms in such cases to pressure of the brachial plexus against the normal first rib. In 1919, Stopford and Telford⁴ reported satisfactory results in these cases by partial removal of the first rib and incomplete section of the scalenus anticus muscle. Honeij,⁵ in 1920, mentioned 19 cases with typical cervical rib symptoms in which a supernumerary rib could not be demonstrated by radiologic examination. Carroll,⁶ in 1932, reported two cases in which the symptoms were attributed to abnormal first ribs. Adson,⁷ in 1933, mentioned the occurrence of the cervical rib syndrome in several cases showing enlarged cervical processes which were relieved by section of the scalenus anticus muscle. In 1935, Ochsner, Gage and DeBakey⁸ published a comprehensive study of the subject to which they gave the name "Scalenus Anticus Syndrome," advancing the latter as a definite clinical entity, the symptoms of which are identical with those of cervical rib. They credit Naffziger with being the first to section the scalenus anticus muscle for the relief of symptoms in absence of a cervical rib. Since 1935 several excellent contributions have appeared in the literature which confirm the scalenus anticus syndrome as a clinical entity.

The purpose of this paper is to present an analysis of 21 consecutive cases of the cervical rib and scalenus anticus syndrome studied during the past two years (Table I). Of the 16 patients that have already received operative treatment, 13 were without cervical ribs, 2 cases showed supernumerary ribs

* Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

Seven of the cases in this series were from the Surgical Division, Section A, of the Hillman Hospital, Birmingham, Ala.

TABLE
ANALYSIS OF 21 CASES OF THE CERVICAL

Case No	Name	Age	Sex	Color	Side Involved	Duration of Symptoms	Unusual Use of Arm or Trauma	Pain + to + + + + Aching	Total or Partial Disability	Numbness
1	L B	38	M	W	R	3 mos	Use	+ + + +	P	+
2	J L	34	M	W	L	6 mos	Use	+ + + +	T	+
3	O \	44	M	W	L	1½ mos	Use	+ + + +	T	+
4	B S	52	M	W	R	3 mos	Use	+ + +	T	o
5	L H	33	M	W	Bilat	11 yrs	Use	+	P	+
6	C W	42	F	W	L	5 yrs	o	++	P	+
7	W S	54	F	W	Bilat	R—3 yrs L—5 mos	o	++	P	+
8	R G	38	F	W	L	6 yrs	Use	++	P	+
9	A C	48	F	W	L	6 mos	o	++	P	o
10	W M	21	F	W	R	5 mos	Anesth	+ + +	T	o
11	J D	50	F	W	L	6 mos	Trauma	+ + +	P	+
12	E D	32	F	W	L	2 yrs	Use	++	P	o
13	E B	24	F	C	Bilat	5 yrs	o	+ + +	P	o
14	R H	15	F	C	R	1 yr	o	+ + +	T	+
15	A F	38	F	C	R	2 yrs	o	+ + +	P	o
16	M F	33	F	C	R	3 mos	o	+ + +	T	o
17	L P	48	F	W	Bilat	6 yrs	o	++	P	+
18	C P	22	M	W	R	2 yrs	Anesth	+ + +	T	+
19	W M	43	F	W	R	7 mos	Use	++	P	o
20	R H	39	F	C	L	3 mos	o	++	P	+
21	A J	32	M	C	L	8 yrs	o	+ + +	T	o

and one presented an abnormal first rib. In the remaining five cases, upon whom operation has been temporarily postponed, two showed roentgenologic evidence of a cervical rib. In addition, 19 cases presenting mild symptoms of this syndrome are reviewed.

Incidence—The age incidence in the 21 cases ranged from 15 to 54 years, with an average of 37 years. The majority occurred in the fourth and fifth decades which showed nine and five cases, respectively. There were 14 female and seven male patients of which five were colored females and one a colored male. The left side alone was involved in nine cases, the right side in eight and bilateral symptoms were present in three instances. A relationship between the onset of symptoms and preceding excessive or unusual use of one of the upper extremities was shown in eight cases. A history of washing and sweeping for a number of years was obtained in five patients classified as domestic servants. The occupations of the others were varied.

I

RIB AND SCALENUS ANTICUS SYNDROME

— Muscular —		— Vascular Changes —		— Neurologic —		X-ray Findings	Results of Operation	Time of relief
Weakness	Atrophy	Pulse	B P Diff	Reflex changes Triceps = T Biceps = B Supinator = S	Diminution Pain and Temp Sensation			
+	0	0	0	0	Median	Neg	3 days	
+	+	0	0	T & S absent	Median	Neg	4 days	
0	0	0	Sl elev	Dim T & B	0	Neg	2 weeks	
+	0	0	3 Elev	B absent	0	Neg	3 days	
0	0	0	8 Elev	0	0	Neg	No oper	
+	0	0	20 Lower	0	Median	Neg	Immed	
+	0	Dim pulse	35 Lower	0	0	Neg	Immed	
+	0	Bilat bruit	30 0	—	—	Neg	Immed	
+	0	0	Lower	—	—	Neg	6 wks	
+	+	Bruit	14 Elev	Rt B & T abs	0	Neg	3 days	
+	+	0	0	0	0	Neg	No oper	
+	0	Bruit	0	0	0	Neg	No oper	
0	0	0	Lower	0	0	Neg	Immed	Periodic mild recurrence
+	0	0	14 0	Rt T & S abs	0	Neg	Immed	recurr 7 mos
0	0	0	0	0	Ulnar median	Neg	1 wk	
0	0	0	4 Elev	0	Ulnar	Neg	Immed	
+	+	0	10 Lower	Left T dim	Ulnar	Abn 1st rib	No oper	
+	+	0	0	0	Ulnar median	Rt cerv rib	No oper	
+	0	0	0	0	Median	Bilat cerv rib	Immed	
+	0	Absent left	Left absent	0	Ulnar median	Bilat cerv rib	Immed	
+	Gangrene	Absent left	Left absent	—	—	Bilat cerv rib	Immed	

and irrelevant. A history of direct trauma preceding the onset of symptoms was given in one case. In two patients the symptoms developed immediately after an anesthesia, one, following an operation for appendicitis under spinal, the other, after a rectal and ether anesthesia during the course of delivery. The first case showed radiologic evidence of a cervical rib on the affected side. The trauma in both of these cases was attributed to faulty position while under the anesthesia with resultant injury to the brachial plexus. Only five patients could be classified as the so-called "anatomic type," namely, long neck and sloping shoulders. Of these, one case showed an abnormal first rib.

Symptoms—The duration of symptoms varied from six weeks to 11 years, with 10 of the 21 cases being seven months or less. The symptoms were variable, and except for the more prominent objective signs in those cases having cervical ribs, were in general essentially the same. The most consistent symptoms were pain, numbness, tenderness on pressure over the

scalenus anticus muscle, slight to marked muscular weakness, and occasional atrophy, with disability chiefly due to the increased pain on motion of the extremity rather than weakness. In addition many of the cases presented inhibited or lost tendon reflexes and diminution of cutaneous sensibility.

Pain—Pain of variable intensity and dull aching in character was the most constant and prominent feature in all except one case. It was characteristically worse at night in 18 cases. The shoulder was the most frequent location of pain, generally over the posterior aspect, with 12 of the cases presenting this as the initial symptom. Pain occurred over the side of the neck in eight cases, arm six, forearm two, arm and forearm three, median distribution of the hand in four and ulnar side in three patients. In the majority of the patients the use of the affected extremity was limited due to the increased intensity of pain on motion. Extension and abduction of the arm in most instances increased the pain. The characteristic attitude was one of adduction of the arm and flexion of the elbow. The most comfortable position at night was similar, with the arm supported on a pillow.

Numbness—Paresthesias, chiefly numbness, occurred in 12 cases, two of the latter were associated with tingling and two with a sensation of coldness. In four patients the numbness extended over ulnar distribution of the hand and in three instances over the median area. In one case the entire hand was involved and in another both hands.

Scalenus Tenderness—Increased tenderness over the scalenus anticus muscle was demonstrated in all cases ranging from moderate to intense pain on pressure.

Weakness and Atrophy—In 14 cases there was a slight to moderate weakness of the affected arm or hand. In the three cases showing symptoms on both sides, a relative increased weakness was found in the arm having the greater pain. Atrophy was marked in two cases, one with cervical rib and the other without. Another case with a cervical rib showed atrophy of the arm and gangrene of the forearm. One patient with an abnormal first rib had considerable atrophy of the hand with trophic changes in the fingers. In the remaining cases it was infrequently observed, and only slight if present.

Reflex and Sensory Changes—Of the 18 cases in which a neurologic examination was made, seven showed changes in the reflexes on the affected side. The triceps reflex was absent in four instances and diminished in two. The biceps reflex was absent in two cases and diminished in one. The supinator reflex was similarly diminished in one instance and lost in two. Operation was followed by a return of function of the inhibited reflexes and partial restoration of those lost, except in two cases where the loss of activity has persisted. Sensory changes, characterized by diminution of pain and temperature sensation, occurred over the cutaneous distribution of the median nerve in four cases, the ulnar in two and both sides in three instances.

Neuroses—In eight of this series there was an associated neurosis. It is interesting to note that there was a definite improvement in the clinical picture of "neurosis" in three of five patients, following operation with relief

of pain The possibility of an associated neurosis causing a distortion of the typical clinical picture of the scalenus anticus syndrome should be borne in mind

Vascular Changes—Of the 18 cases in which blood pressure readings were recorded in both arms, six patients showed a decrease, averaging 15 points, and five showed an elevation of the blood pressure reading, averaging eight points on the affected side In the majority of instances, the radial pulse could be obliterated or greatly diminished by having the patient turn the head toward the involved side and take a deep breath, or by deep pressure over the insertion of the scalenus anticus muscle Neither of these tests, however, was considered of great significance, in that they can be demonstrated in asymptomatic cases A distinct bruit was heard in the supraclavicular fossa of three patients Three cases, showing advanced changes attributed to compression of the subclavian artery, deserve special comment In one patient with bilateral symptoms a loud bruit could be heard over the supraclavicular fossa on both sides The right radial pulse was almost imperceptible Blood pressure was 90/70 on the right and 120/70 on the left side At operation both subclavian arteries were found to be markedly constricted and sclerosed There was no other evidence of circulatory disease The bruits have persisted The patient was completely relieved of symptoms, and an arthritis of the left shoulder, attributed to atrophic changes from prolonged disuse, cleared up rapidly In another case in which symptoms on the left side were associated with bilateral cervical ribs, there was an absence of pulse and blood pressure readings in the affected arm At operation the subclavian artery was found to be small and sclerotic The scalenus anticus muscle was tremendously hypertrophied Immediately after operation, blood pressure reading in the affected arm was found to be 80/60 and a faint pulsation could be palpated over the radial artery The third case presented a complete obliteration of the subclavian artery with resulting gangrene of the forearm Because of the striking clinical course it is presented in detail

Case Report—Extensive gangrene of hand and forearm resulting from compression of subclavian artery between the scalenus anticus muscle and a cervical rib

A J, colored, male, age 32, was admitted to the Surgical Division, Section A, Hillman Hospital, April 19, 1938, with gangrene of left hand, associated with severe pain Present illness began eight years ago with pain in left arm and hand which disabled him for work at intervals Seven months before admission, he developed severe pain and gangrene of the left middle finger Gangrene gradually spread to involve the entire hand Pain had been severe for the past two months, made worse by lying in a prone position Examination revealed gangrene of left hand with a foul smelling discharge There was atrophy of muscles of left arm, absent pulsations in left upper extremity and diminished temperature in left arm Blood pressure in right arm 160/90, temperature 101° F, pulse 90 A bony prominence could be palpated in left supraclavicular fossa The patient left the hospital two days after admission He returned, August 15, 1938, with an extension of gangrene up to a point just below the left elbow The middle third of the left ulna and radius was exposed Motion was good in left elbow There was marked atrophy of the left arm and shoulder girdle (Fig 1A, B and C) Roentgenologic examination revealed bilateral cervical ribs, the left being incomplete and attached to the

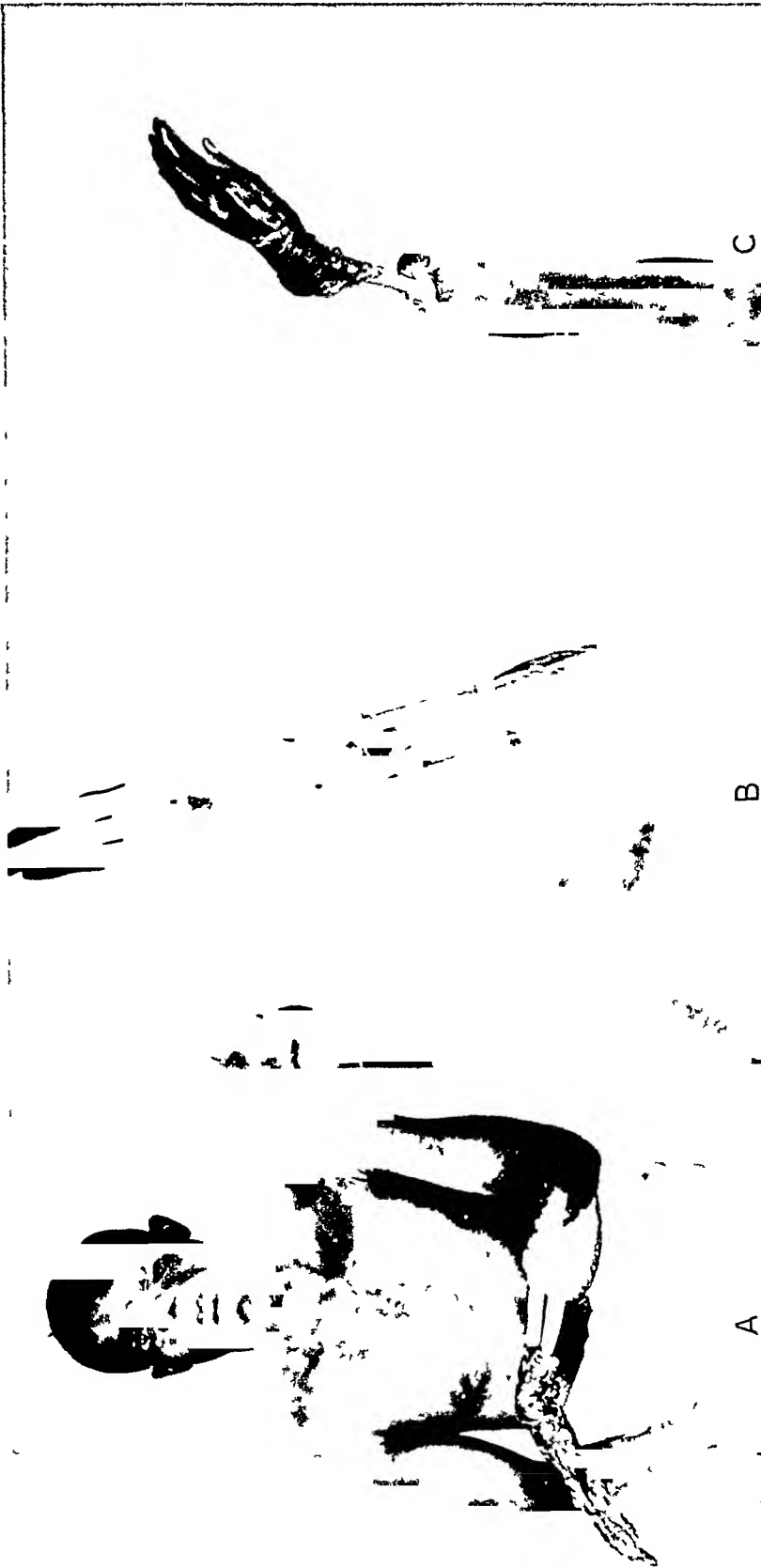


FIG 1.—Extensive gangrene of the left hand and forearm resulting from compression of subclavian artery between the scalenus anticus muscle and a cervical rib. Bilateral cervical ribs were present.

first rib (Fig 2A and B), and a fracture of the left ulna and radius at the line of demarcation below the elbow (Fig 3) This was apparently spontaneous, as there was no history of trauma On August 18, 1938, the left forearm was amputated under

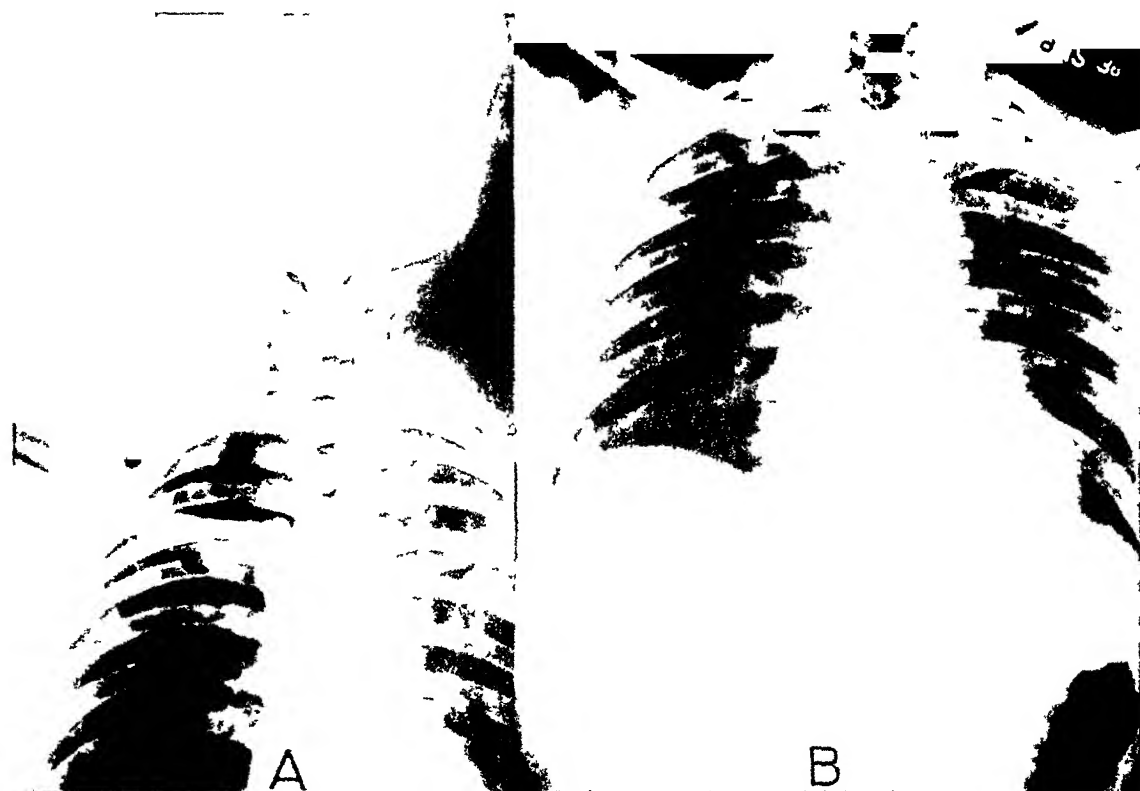


FIG 2—Roentgenograms of the patient with extensive gangrene of the left forearm A Bilateral cervical ribs—right complete left incomplete and attached to the first rib B The distal portion of the left cervical rib has been removed—relieving pressure on the subclavian artery and brachial plexus



FIG 3—Spontaneous fractures of the left radius and ulna at the line of demarcation of the gangrene

sodium pentothal anesthesia As much of the soft tissue as possible was conserved There was no pulsation in radial or ulnar arteries at their origin Collateral circulation appeared to be good Six days later a tenotomy of left scalenus anticus muscle and

resection of distal portion of left cervical rib was performed, again using sodium pentothal anesthesia. The scalenus anticus muscle was not hypertrophied. This procedure did not completely relieve pressure on the subclavian artery and brachial plexus which were pushed forward from behind by the cervical rib, causing the artery to be flattened out and completely obliterated. No pulsation could be demonstrated distal to the rib. The artery was smaller than normal where the scalenus anticus muscle crossed it. The rib was partially removed allowing the structures to resume their normal position.

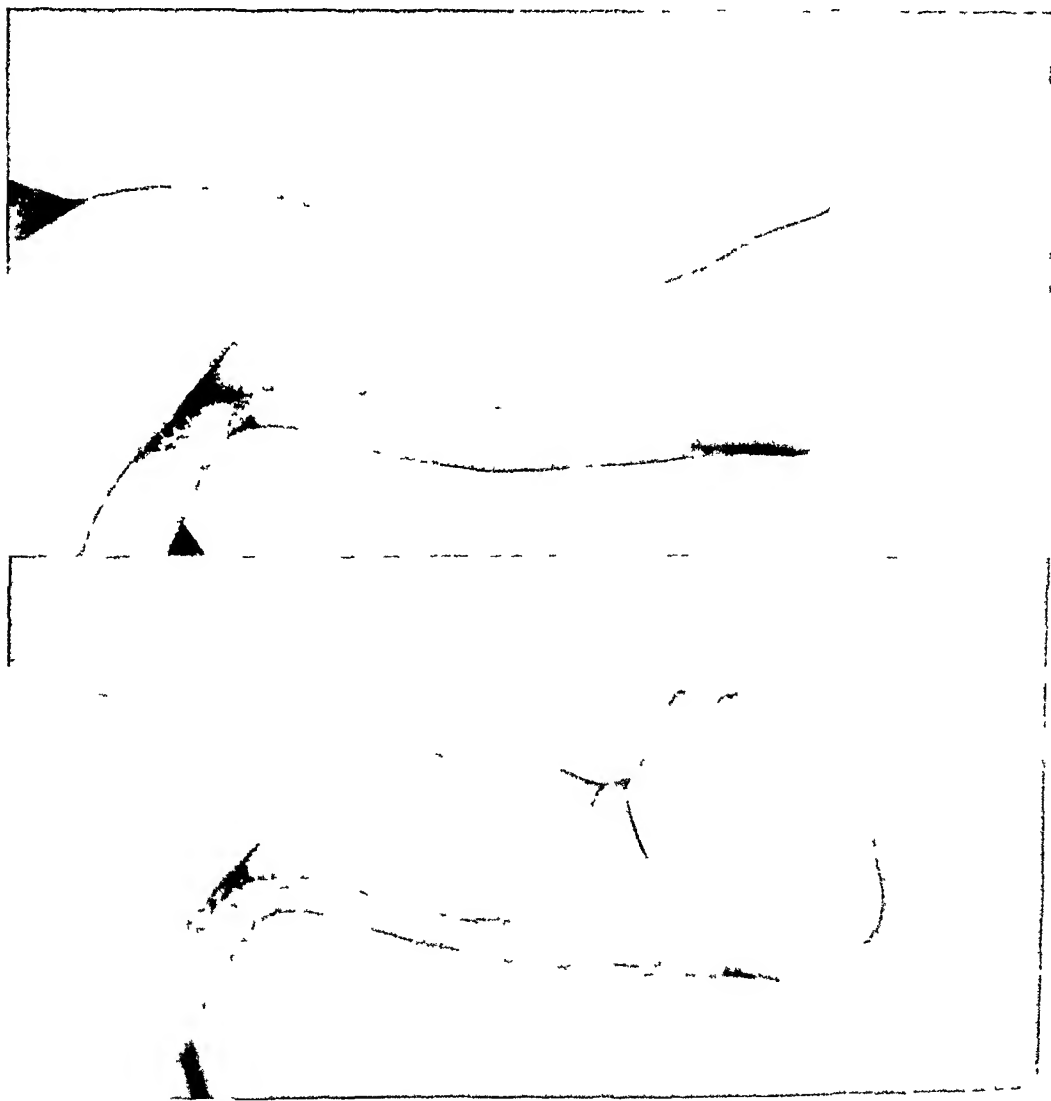


FIG 4—Final result, patient has normal motion in the elbow

Pulsation was questionable after the compression was relieved. The amputated stump of the forearm healed completely in 17 days. Pulsation in the left brachial artery was obtained soon after operation. The patient has since remained well and free of symptoms (Fig 4). He has worked regularly as a truck driver with the use of an artificial arm.

It was thought that absence of definite hypertrophy and tenseness of the scalenus anticus muscle usually observed in these cases was apparently due to an advanced stage of the syndrome when all the muscles of the left shoulder

der girdle and arm had become atrophic. This case typifies those rare instances in which the rib must be removed in addition to tenotomy of the muscle to relieve compression.

Röntgenologic Examination—Bilateral cervical ribs were demonstrated in three patients. Of these, two presented symptoms on the left side, one, a colored female, with absence of radial pulse and blood pressure reading on the affected side (Fig 5 A and B), and the other, a colored male mentioned above, with an extensive gangrene of the forearm. The third patient, a white female, showed symptoms on the right, with a Horner's syndrome.

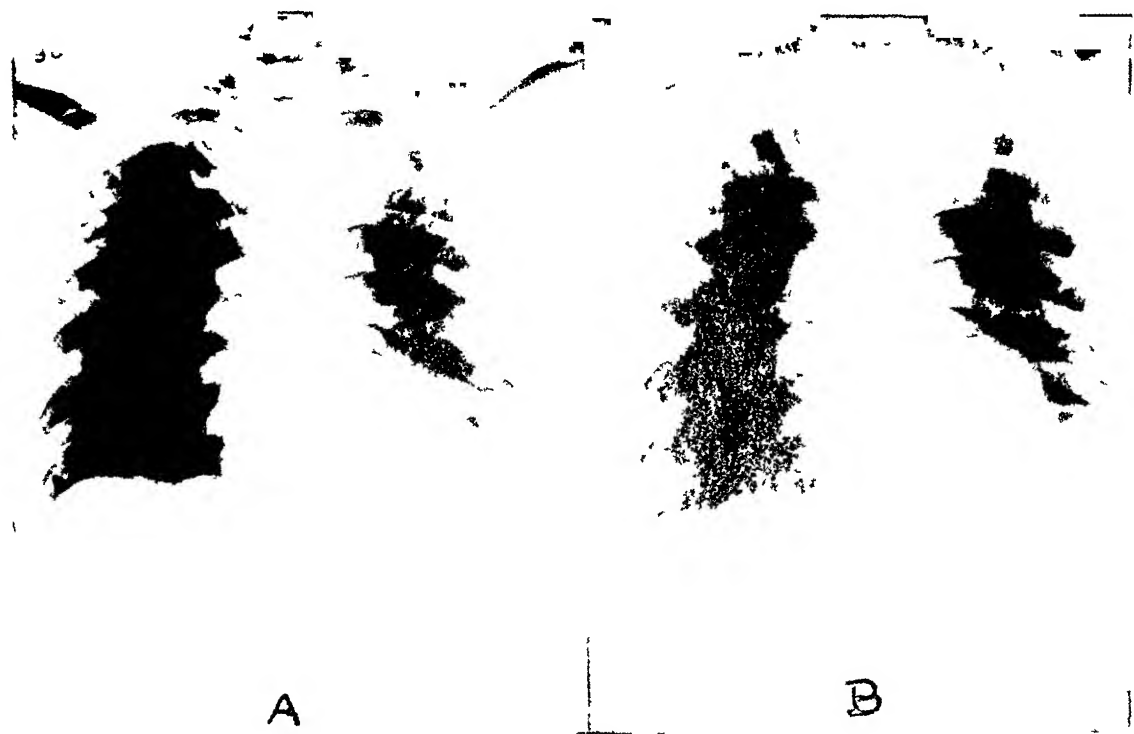


FIG 5—Bilateral cervical ribs. This patient had left syndrome with absence of blood pressure and pulse in left upper extremity. A Before scalenotomy. B After scalenotomy showing elevation of left diaphragm due to temporary paralysis from traction on left phrenic nerve at time of operation.

on the affected side. One case showed a right cervical rib with extensive symptoms in right arm simulating syringomyelia (Fig 6). Another patient with bilateral symptoms was found to have an abnormal first rib on the side showing the more marked symptoms (Fig 7). In the 16 remaining cases there was no evidence of supernumerary ribs. The symptoms in these cases were essentially the same as in those with cervical ribs, except that the objective findings were less marked. It should be emphasized that cervical ribs, when bilateral, may offer a real difficulty in roentgenologic diagnosis unless one is looking for the anomaly. It may be necessary, at times, to get a complete picture of the chest to show all the ribs before we can be certain of the diagnosis.

Operative Procedure—The operative technic was essentially that described by Adson and Coffey,² and Ochsner, *et al*.⁵ A 1 per cent novocain infiltration was employed in 11 cases, sodium pentothal in three, cyclopropane in one, and nitrous oxide in one. It should be borne in mind that the scalenus anticus

muscle is deeply situated. It can be palpated beneath the overlying fat pad which is a good guide to exposure. The muscle is easily identified by the phrenic nerve which passes obliquely across it from the lateral surface medially. After the muscle has been exposed it is sectioned in layers through the tendinous attachment. A blunt pointed aneurysm needle lends itself well to this procedure. It is passed through only parts of the muscle at a time from the medial surface laterally. The subclavian artery comes forward into view in most instances after all fibers of the muscle have been divided.

We have found it quite easy to go too far medially in getting down to the muscle. In one case of left scalenus anticus syndrome the thoracic duct was



FIG. 6—Right cervical rib (posterior view). This patient presented extensive atrophy of the right hand and arm simulating syringomyelia.



FIG. 7—Bilateral scalenus anticus syndrome in a patient with an incomplete first dorsal rib attached to the second dorsal rib causing a prominence in the left supraclavicular fossa.

accidentally lacerated. The wound rapidly filled with clear lymph, the patient having fasted for 12 hours before the operation. The accident was discovered at the time and the thoracic duct was ligated. No symptoms developed as a result of ligation of the duct and the patient made an uneventful recovery. Silk was used in 13 of the cases and catgut in three. We feel that silk is definitely superior to catgut in these cases because of minimum tissue reaction following its use. No drains were used in any of the cases.

Spurling and Bradford⁹ call attention to the temporary paralysis of the diaphragm in these cases following traction on the phrenic nerve and advise against bilateral tenotomy of the muscle in one stage. We confirmed this observation in each of four cases in which fluoroscopic and roentgenologic examinations were made (Fig. 8 A and B). In the three cases of bilateral syndrome in our series, however, both muscles were sectioned at one time

with no apparent after-effect Craig and Knepper¹⁰ have previously reported cases in which bilateral scalenotomy was performed at one operation

Pathology—In all cases, except the one with extensive gangrene and wasting of the muscles of the neck shoulder and arm, the scalenus anticus muscle was found to be hypertrophied and tense In some cases the hypertrophy was more marked than in others and bore a definite relationship to severity of symptoms Specimens of nine sectioned scalenus anticus muscles were examined microscopically The changes were, in general, insignificant Small scattered areas of fibrosis were found in three cases One of these showed a prominent thickening of the arterioles Two other cases had moderate arteriosclerotic changes The histologic picture of the others was essentially negative

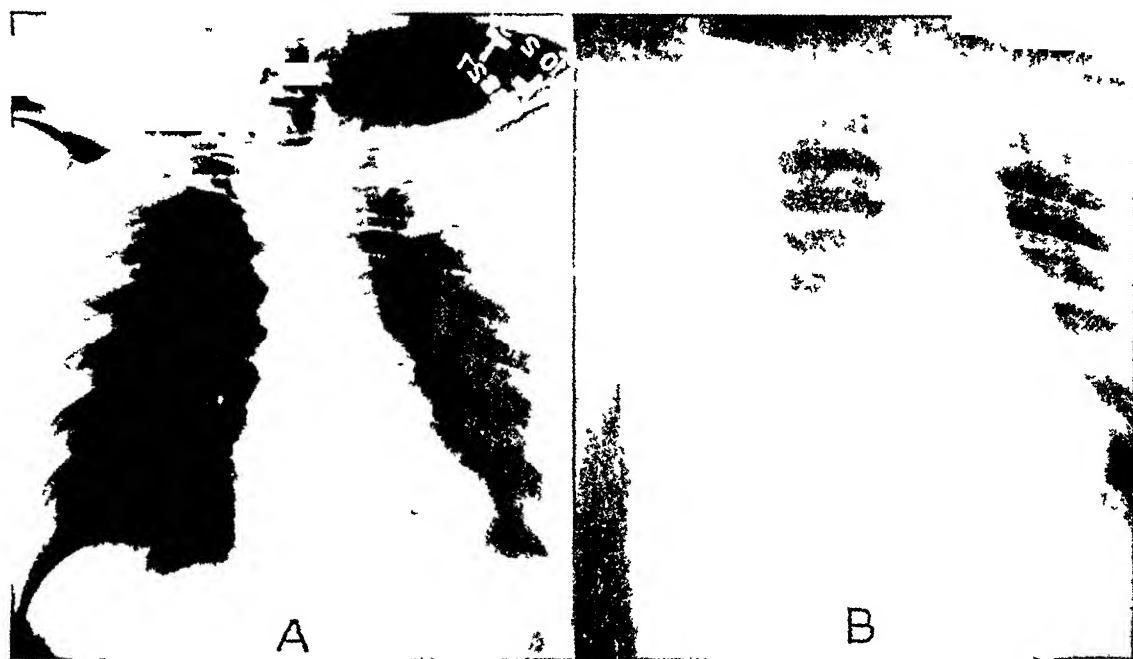


FIG 8—A Elongated seventh cervical transverse processes, especially the right, in a patient with right scalenus anticus syndrome B Elevation of right diaphragm following scalenotomy due to traction on phrenic nerve

Operative Results—Of the 16 cases submitted to operation, 14 have been completely relieved of all symptoms The relief of pain immediately followed section of the muscle in nine patients, and in three instances complete relief was obtained before leaving the hospital, the average stay being four to five days In one case symptoms persisted for one week after leaving hospital, in another, complete relief was obtained two weeks after the operation, and in a third, mild symptoms persisted for six weeks after tenotomy In the two cases showing recurrence of symptoms, one developed seven months after operation, following excessive use of the affected arm Symptoms persisted for a period of two months before gradually subsiding In another case, operated upon one year ago, mild pains at infrequent intervals have persisted since resumption of her previous occupation as a domestic servant

Mild (Nonsurgical) Cases—In addition to the above reported cases, 19 patients were examined who were considered as having symptoms of a mild

scalenus anticus syndrome, in which surgery was not indicated. Their ages ranged from 16 to 47 years, with an average of 35 years. Of these, 15 occurred in the fourth and fifth decades. There were 13 females and six males. Symptoms were present on the right side in six cases, left six, and were bilateral in seven. Of those showing symptoms on both sides, the left side was more prominently affected in four cases. Pain, aching in character and subject to remissions, was found in all cases. It was worse at night in six patients, the most frequent location being, in order, the shoulder, neck and arm. A sensation of numbness was present in nine instances and coldness

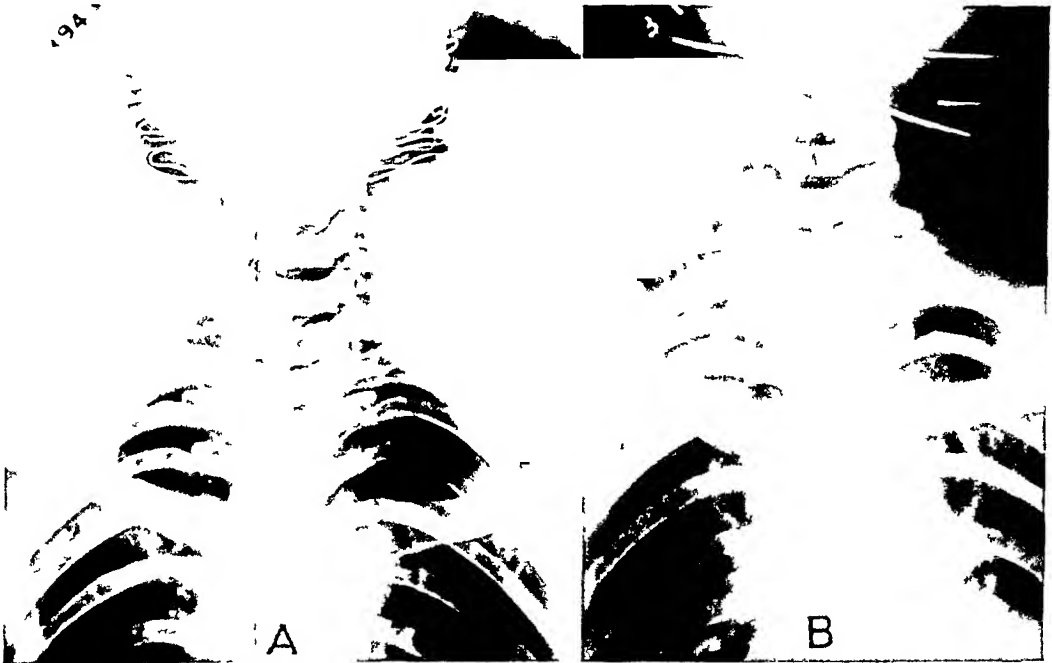


FIG 9—A and B Identical left cervical ribs and elongated right seventh cervical transverse processes in identical twin females, with mild symptoms in their left arms

of the hands in two. The symptoms ranged in duration from one month to 15 years, with 12 being six months or less. Aside from the finding of a supraclavicular bruit in three cases, and increased scalenus tenderness in all instances, the objective signs were essentially negative. Of interest, was the presence of a supernumerary rib in identical twins, 32 years of age, each of whom showed roentgenologic evidence of a left cervical rib (Fig 9 A and B). None of six other patients who had roentgenologic examinations in this series showed the presence of a supernumerary rib. One patient presented attacks simulating angina pectoris. Although the increased intensity of symptoms in some of these cases may eventually necessitate operative relief, approximately 60 per cent of them have shown a considerable improvement following symptomatic treatment and improvement of posture. A few have been completely relieved.

Discussion—It is assumed that the scalenus anticus syndrome is found in patients having inherent anatomic and developmental variations about the shoulders, although this is frequently not demonstrable. It is well known

that symptoms are found more frequently in women, rarely before the age of 20, and that most cases occur between the ages of 20 and 40. Todd¹¹ attributed the development of symptoms to an abnormally low position of the shoulder and high fixation of the sternum and ribs. The shoulder girdle descends farther in women, therefore, it may be expected that the syndrome will be encountered more frequently in women. The so-called "anatomic type," mentioned by Freiberg,¹² characterized by sloping shoulders and long neck, was seen in but five of our 21 cases. The others presented no unusual external type. Jones¹³ believed a low origin of the brachial plexus to be responsible for the development of symptoms. Ochsner, Gage and DeBakey⁸ claim the exciting factor to be an elevation of the first rib due to spasm of the scalenus anticus muscle resulting from brachial plexus irritation. Gage¹⁴ has been able to demonstrate a temporary relief of pain in three cases by the injection of a 1 per cent novocain solution into the scalenus anticus muscle. Freiberg¹² believes that the scalenus anticus syndrome occurs as a sequela of primary lesions of the shoulder joint and cervical spine more frequently than as an isolated clinical entity. He points out that the symptoms frequently disappear after local therapy to lesions of the cervical spine and shoulders. Although these significant factors must be borne in mind, it is interesting to note the clinical improvement of two cases of arthritis of the shoulder joint in our series associated with the scalenus anticus syndrome, following scalenotomy. Direct trauma preceding the onset of symptoms could be demonstrated in only one of our 21 cases. In two others the trauma was attributed to faulty position while under anesthesia, followed immediately by the development of symptoms typical of the syndrome. The frequency and importance of trauma, as a precipitating factor, has been stressed by Honeij,⁵ Spurling and Bradford,⁹ Naffziger and Giant,¹⁵ and others. Excessive occupational strain, whether considered traumatic or responsible for a muscular imbalance of the shoulder, is also a significant factor, as demonstrated in eight of our cases. The reason for the preponderance of cases in our series in the fourth and fifth decades may possibly be attributed to regressive muscular changes occurring in the ages between 30 and 50 with resulting drooping of the shoulders. The characteristic increase of pain at night in the majority of the cases may be accounted for by the pressure from behind, as the shoulders are brought forward against the scalenus anticus muscle while in the prone position.

The symptoms of cervical rib and scalenus anticus syndrome are similar. In both conditions we are probably dealing with inherent anatomic and developmental variations which represent the fertile soil for the development of symptoms precipitated by such factors as trauma, occupational strain and improper posture. In our series of cases the more extreme brachial plexus and circulatory disturbances have been noted in patients with cervical ribs, suggesting that symptoms are apt to be more marked in the presence of a supernumerary rib. The symptoms result from compression or irritation of the brachial plexus and compression of the subclavian artery. Telford and Stop-

ford¹⁶ attribute the vascular changes to irritation of the sympathetic fibers of the brachial plexus rather than to direct pressure on the artery

In view of the fact that the scalenus anticus muscle is the primary factor in the production of neurocirculatory compression, regardless of whether a cervical or abnormal first rib is present, it would seem appropriate to group all of these cases under the term "Scalenus Anticus Syndrome" and designate whether a cervical rib or abnormal first rib is associated. The surgical indications are the same and results have usually been excellent. Indiscriminate scalenotomy in all cases exhibiting the syndrome is certainly not indicated, as many of the cases are mild and will respond to conservative therapy. It has been our experience that the symptoms in the milder cases are not progressive, but subject to remissions and exacerbations.

This study indicates that the symptoms of the scalenus anticus syndrome occur with much greater frequency without the presence of a cervical rib. The syndrome accounts for many cases of pain and unexplained vascular disturbances in the upper extremities. On account of the frequent gradual onset and bizarre picture present in some cases, it is often difficult to make a positive diagnosis. In some cases we have kept patients under observation for several months before any definite conclusions were made. A neurologic examination is urged in all cases. The conditions causing the most difficulty in the differential diagnosis have been infectious neuritis, arthritis of the shoulder joint, cervical arthritis, subacromial bursitis and neuroma.

SUMMARY AND CONCLUSIONS

(1) Twenty-one cases presenting symptoms of the scalenus anticus and cervical rib syndrome are reviewed.

(2) Sixteen cases were not associated with a cervical or abnormal rib, indicating that the scalenus anticus syndrome occurs with much greater frequency than the cervical rib syndrome.

(3) Although the symptoms of the scalenus anticus and cervical rib syndromes are similar, objective findings are apt to be more marked when associated with a cervical rib.

(4) The symptoms are the result of compression of the brachial plexus and subclavian artery by the scalenus anticus muscle.

(5) The symptoms are precipitated by such factors as trauma, occupational strain and improper posture in patients having inherent anatomic and developmental variations about the shoulders.

(6) In view of the essentially identical etiologic factors and clinical picture of the scalenus anticus and cervical rib syndromes, it is suggested that the term "Scalenus Anticus Syndrome" be applied to both conditions with the occurrence of a rib, if present, specified.

(7) The scalenus anticus syndrome appears to be more frequent than is generally recognized and is a common cause of brachial plexus neuritis and unexplained vascular disturbances of the upper extremities.

(8) The results following scalenotomy have been excellent. Fourteen of the cases have been completely relieved of symptoms. One has had a recurrence of two months' duration, seven months after operation, the other has complained of mild symptoms at infrequent intervals.

(9) Scalenotomy in all cases is not indicated as many are mild and respond to conservative therapy.

(10) Remissions and exacerbation of symptoms are characteristic of the mild cases.

REFERENCES

- ¹ Murphy, J. B. The Clinical Significance of Cervical Ribs. *Surg, Gynec, and Obstet*, 3, 514, 1906.
- ² Adson, A. W., and Coffey, J. R. Cervical Rib, a Method of Anterior Approach for Relief of Symptoms by Division of the Scalenus Anticus. *ANNALS OF SURGERY*, 85, 839, 1927.
- ³ Cited by Brickner, W. M., and Milch, H. First Dorsal Simulating Cervical Rib—by Maldevelopment or by Pressure Symptoms. *Surg, Gynec, and Obstet*, 40, 38, 1925.
- ⁴ Stopford, J. S. B., and Telford, E. D. Compression of the Lower Trunk of the Brachial Plexus by a First Dorsal Rib. *Brit Jour Surg*, 7, 168, 1919.
- ⁵ Honeg, J. A. Cervical Ribs. Presentation of Cases and a Bibliography. *Surg, Gynec, and Obstet*, 30, 481, 1920.
- ⁶ Carroll, W. C. Cervical Ribs and Abnormal First Thoracic Ribs. *Minn Med*, 15, 828, 1932.
- ⁷ Adson, A. W. Surgical Treatment of Cervical Ribs. *Texas State Med Jour*, 28, 739, 1933.
- ⁸ Ochsner, A., Gage, M., and DeBakey, M. Scalenus Anticus (Naffziger) Syndrome. *Am Jour Surg*, 28, 669, 1935.
- ⁹ Spurling, R. G., and Bradford, F. K. Scalenus Neurocirculatory Compression. *ANNALS OF SURGERY*, 107, 708, 1938.
- ¹⁰ Craig, W. McK., and Knepper, P. A. Cervical Rib and the Scalenus Anticus Syndrome. *ANNALS OF SURGERY*, 105, 556, 1937.
- ¹¹ Todd, T. W. The Descent of the Shoulder After Birth, Its Significance in the Production of Pressure Symptoms on the Lower Brachial Plexus. *Anat Anz*, 41, 385, 1912.
- ¹² Freiberg, J. A. The Scalenus Anticus Muscle in Relation to Shoulder and Arm Pain. *Jour Bone and Joint Surg*, 20, 860, 1928.
- ¹³ Jones, F. W. On the Relation of the Limb Plexus to the Ribs and Vertebral Column. *Jour Anat and Physiol*, 44, 377, 1909.
- ¹⁴ Gage, M. Scalenus Anticus Syndrome, A Diagnostic and Confirmatory Test. *Surgery*, 5, 599, 1939.
- ¹⁵ Naffziger, H. C., and Grant, Wm. T. Neuritis of the Brachial Plexus Mechanical in Origin. The Scalenus Syndrome. *Surg, Gynec, and Obstet*, 67, 722, 1938.
- ¹⁶ Telford, E. D., and Stopford, J. S. B. The Vascular Complications of Cervical Rib. *Brit Jour Surg*, 18, 557, 1931.

THE CERVICOBACHIAL SYNDROME *

A DISCUSSION OF THE ETIOLOGY WITH REPORT OF TWENTY CASES

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NAFFZIGER,³⁹ in a recent paper, clearly limits the scalenus syndrome to cases suffering from neuritis of the brachial trunks. However, since there are a number of pathologic conditions besides the compression of the scalenus anterior muscle which may produce identical symptoms, the Naffziger terminology, therefore, is too limited.

The vascular and nerve trunk symptoms should be expressed in a more inclusive terminology. The term "cervicobrachial syndrome" does not define the diseases but it does give a comprehensive and an anatomic concept which is accurate and inclusive.

The 20 cases included in the paper comprise 12 of my own and eight cases which occurred in the practice of my colleagues in the Providence Hospital. All of these cases have come under my observation before operation and the diagnosis was confirmed either by operation or by subsequent history. My cases include four which were operated upon by me for cervical rib prior to the understanding of the rôle which the scalenus anterior muscle exercises in the symptomatology or in the pathology.

The first case, seen in 1914, was a male railroad employee, who was injured in a wreck by falling on the left shoulder. Subsequently, the left arm became very painful, swollen, useless, and obliged him to stop working. He complained of severe pain in the left shoulder and left arm, especially in the medial side, pain and stiffness in the little and ring fingers, *etc.* Roentgenologic examination showed bilateral cervical ribs, the left was a complete rib articulating with the first rib, in the supraclavicular fossa was a hard, tender, slightly pulsating mass, which, he claimed, caused intense pain down the inner side of the arm. Accurate records were not made at the time. The diagnosis was neuritis of the brachial plexus, especially the lower trunks, due to the injury. Resection of the left cervical rib by the old technic relieved the symptoms. It was several months before the patient returned to his regular occupation. This was clearly a case due to traumatism. The other three cases gave similar histories, as all of them were injured by falling on or by being struck on the shoulder. Their histories offer no additional interest as they were treated by removal of the affecting cervical rib and were diagnosed as cervical rib cases. Two of these patients were under observation until they returned to their regular duties several months later, the other patient was not observed and the results are not known. All of them gave histories of having been well and regularly on duty as railroad laborers before the injury.

* Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

The other 16 cases have come under observation since the rôle of the scalenus anterior muscle has been suggested by a number of writers. Every case has been studied carefully and ten cases confirmed by operation, with relief of symptoms, except one case which had only partial relief. In all of the cases not operated upon, the same diagnostic criteria were insisted upon to make the diagnosis as were those operated upon. Roentgenologic examinations confirmed the presence of cervical ribs, when present, the neurologic and vascular examinations elicited the same findings as those who were operated upon.

The following type-cases are reported to illustrate the theories of the etiology and the course of the ailment. All of them gave a history of traumatism.

ILLUSTRATIVE CASE REPORTS

Case 1—*The Neurologic Type* A female, age 65, had always been in fairly good health, except that she had suffered during recent years from multiple arthritis associated with high blood pressure.

In October, 1935, she fell down the stairway and struck the left shoulder and the left side of the body, she felt very sore and bruised for a few days. About four weeks later, she drove an automobile to Michigan. She then began to suffer from a dull, aching pain in the *right side* of the neck. The pain became severe within a few days, especially at night. A few weeks later, the pain had spread into the shoulder and down into the arm, forearm and hand, and up the side of the neck. She noticed swelling and tenderness as well as pain in the entire arm, but more severe in the inner side of the entire arm and hand. The pain was more severe in the shoulder and upper arm. She felt numbness, tingling and tenderness of the skin, which was slightly cyanotic. She noticed disturbed tactile sensations, especially in the hand, but most marked on the ulnar side and in the little and ring fingers. She now had a constant ache in the arm and kept it in a sling strapped to her side. She consulted a physician in January, who first strapped the arm firmly to her side, which gave no relief, then he applied a Velpeau splint, which gave no relief, and the shoulder joint became quite stiff. Then baking and diathermy were used, with no benefit.

Physical Examination—The patient is a rather stout, well-nourished woman with the right arm carried in the left hand. She complains on the least movement of the right arm. It is moderately swollen below the elbow, especially the hand and fingers, the skin is dusky and definitely cyanotic and pits on pressure. The arm is held close to the body, the elbow is flexed and the hand about half closed. Any movement of the joints is painful. The pulse varies from 80 to 90, the blood pressure in the right arm is 150/90 and 160/90 in the left arm. There is a definite pulsating swelling in the right side of the neck along the line of the carotid artery which has been diagnosed as an aneurysm. There is moderate tenderness in the supraclavicular fossa, but no mass is palpable. With head erect and turned to the right, pulsation in the right radial artery was absent. All reflexes in the arm were normal. Roentgenologic examination showed no cervical rib on either side. The diagnosis was scalenus anterior syndrome. At operation, the scalenus anterior muscle was severed from its attachment to the first rib according to the technic of Adson.¹⁶

Comment—The scalenus anterior muscle was greatly enlarged, somewhat fibrous, and apparently tenser than normal. About one-half inch of the muscle was removed. The attachment of the lateral fibers of the scalenus anterior was very broad and fibrotic. When the muscle was cut through and one-half inch removed, it contracted and the subclavian artery rose up in a wide curve over the first rib and seemed to expand in

size The two lowest nerve trunks were carefully freed from a small amount of fibrous tissue

Postoperative Course—The recovery from pain was noted the afternoon of the operation and within a week the patient was discharged Since then she had been well

This report gives a succinct history of injury by *indirect* force to the scalenus anterior muscle which resulted in muscular contraction which compressed the lower nerve trunks and caused the symptoms outlined above There was no cervical rib or pressure on a normal first rib which would produce the symptoms which were presented

*Case 2—The Vascular Type*⁹ A female, age 44, was examined May 31, 1938, she had always been in good health, except for typhoid fever at age 17 She had noticed a painless, but pulsating swelling in the right supraclavicular fossa about ten years previously, following a very difficult and prolonged labor, during which she felt a very severe, cutting pain in the right side of the neck while she was pulling on obstetric straps She complained of soreness and tenderness in the right side of the neck for some weeks, especially when she would turn her head

The swelling in the neck gave no trouble, although it had slowly increased in size until about eight months ago when she began to have tingling pains in the swelling which rapidly radiated into the shoulder, the entire arm, hand and fingers, but was felt more in the inner side of the arm and hand and in the little and ring fingers, although the whole hand was affected The fingers and hand became cold and numb Although the pain was always a more or less severe aching, worse after using the arm, it changed at times from the side of the neck to the shoulders, elbow, etc She complained of dizziness, right-sided headache, and "roaring" in the head at times The pain was constant day and night Her physician had told her she had no right pulse

She had consulted several physicians who administered roentgen therapy, diathermy, etc, but with no relief The pain had become more severe and the arm almost useless during the last few weeks

Physical Examination—The patient was of a rather fleshy, stout type and appeared to be in good health, but supported the right arm in the left hand Temperature normal, left pulse 70, the right hardly perceptible, but 70 The blood pressure 142/70 in the left arm, it could not be ascertained in the right arm because of instant pain from the arm hand and the arm became very cyanotic There was no edema and very little tenderness except over the olecranon which was hypersensitive There was a visible, tender, pulsating mass in the right supraclavicular fossa about 5 cm in size which extended beneath the clavicle She was most comfortable with the arm hanging down Roentgenograms showed bilateral cervical ribs The patient refused treatment

Examination One Week Later—The blood pressure in the left arm was 142/74, the right pulse could not be felt She now complained of greater pain in the shoulder neck, and in the right side of the head The pulsating mass in the right supraclavicular fossa had not changed The laboratory findings are normal, Wassermann test negative Roentgenologic examination by another laboratory confirmed the diagnosis of bilateral cervical ribs, the left one was small, the right one was large, complete, and articulated with the first rib in front (Fig 1) The diagnosis was (1) Aneurysm of the right subclavian artery, (2) bilateral cervical ribs, (3) neuritis of the right brachial plexus, lower two trunks Removal of the right cervical rib and section and removal of one-half inch of the scalenus anterior muscle were effected

Comment—The Adson incision was employed The arterial swelling was an aneurysm about one inch long and one inch in diameter, which was definitely limited distally beneath the clavicle, which was lying close to the first rib When the scalenus anterior muscle was severed, the artery rose up into a rather high arch across the



FIG 1—*Case 2* Roentgenogram showing two well developed cervical ribs. The left one is short and does not articulate with the first rib. The right one is very large, long and articulates with the first rib.

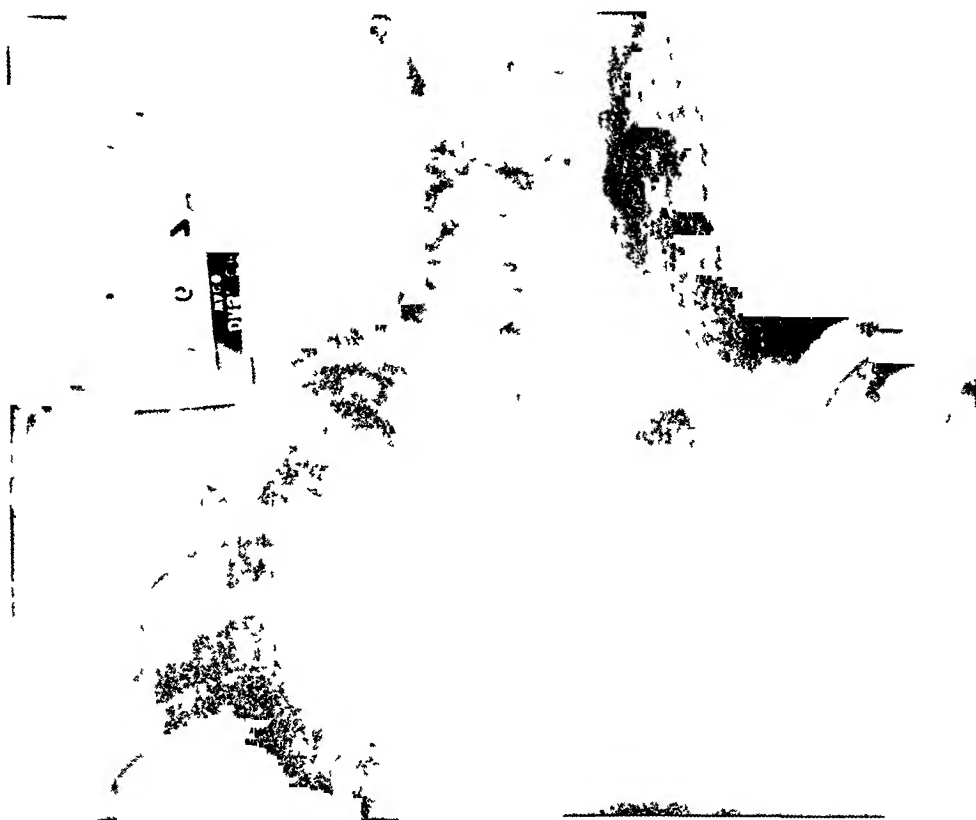


FIG 2—*Case 2* Roentgenogram showing the result of the removal of most of the right cervical rib.

fossa but there was still obstruction to it as it crossed the cervical rib. When the cervical rib was removed (Fig 2), the aneurysmal artery formed a smaller arch than before the rib was removed, as its distal end lay lower. The scalenus anterior muscle was not enlarged but had a wide attachment and cut like fibrous tissue, with wide retraction of the upper end which furnished more space for the dilated aneurysmal artery. The scalenus medius appeared to be fibrous but it was not incised. The wall of the aneurysm did not show any areas of calcification or other degeneration, although they were carefully searched for.

Subsequent Course—The patient has made a most satisfactory recovery. Six months later, she had, as residual effects, some stiffness of the shoulder, inability to elevate the arm above the chin, but she had no pain, no limitation of arm movements below the level of the shoulder, and the pulse had returned. The mass in the supraclavicular fossa was apparently smaller and the pulsations were not noticed by the patient.

Follow-Up—November 29, 1939. She can use the arm in any position with no discomfort. The right hand is normal, it feels colder than the left. There is no pulse appreciable in the right radial artery. Blood pressure in the right arm 104/88, left 144/96. There is no pulsation in the supraclavicular fossa.

Comment—This case was probably due to traumatism, during labor, to the scalenus anterior muscle resulting in fibrous tissue formation and contraction over a long period of time. In this case the vascular symptoms were definite and were relieved by resection of the tense scalenus anterior muscle and the removal of the obstructing cervical rib. The results have been the relief of all of the symptoms although the aneurysm has decreased in size only slightly. The aneurysm was not removed because the vessel walls did not appear to be seriously diseased and it was thought that the vascular symptoms would be relieved by the operation.

Case 3—Traumatic Newt's Type A physician, age 50, said that he had always been in good health until December 2, 1938, when he fell from the top of a seven-foot fence, landing on his right shoulder on a brick pavement, he had severe pain in and around the right shoulder for several days following the injury. After one week the pain and soreness subsided and for six weeks he suffered no inconvenience. During the latter part of January, or during the first week of February, he began to have pain in the right deltoid region, in the shoulder, over the flexor surface of the right elbow joint and slight pain down the flexor surface of the arm to the wrist joint. It was moderately severe, but constant. He continued to drive his car, but the pain was serious enough to keep him awake at night. After this pain had been present for about two or three weeks, while running, he again fell, striking the point of the right shoulder against the ground. Following this, the pain became rapidly worse. He consulted Dr. E. P. Bunkley, of Stamford. The patient continued with his duties although he had employed a chauffeur during the last few weeks.

He kept the arm in complete adduction constantly with the forearm flexed to a right angle, with the hand lying across the abdomen, the hand and fingers were edematous and the right arm was one-half larger than the left. Any voluntary movements of the arm, except in the anterior position, caused extreme pain in the arm and shoulder, this was especially marked when the arm was voluntarily abducted or moved backwards. He had radiating pains through the right side of the neck and into the shoulder when the head was rotated to the right side with the chin extended. There was partial skin paresthesia over the whole deltoid region, the anterior surface of the arm, over the flexor surface of the elbow joint, and down the surface of the forearm to within two or three inches of the wrist joint. The examination otherwise was negative.

About the middle of April, the patient was seen in consultation. Examination confirmed the above history and findings. There was a definite, hard, tender area in the right supraclavicular fossa but no pulsation. The hand and forearm were edematous and tender over the whole area of the region of pain. He held the arm in flexion, adduction, and flexed across the abdomen. There was no change in the pulse in either arm, there was marked tenderness over the distribution of the fifth, sixth, and seventh cervical nerve trunks.

Roentgenologic examination showed bilateral cervical ribs, arthritis of the cervical spine, and a destructive process in the third thoracic vertebra, probably due to an old injury. A diagnosis of scalenus anterior syndrome, due to injury, associated with cervical ribs, was made. Section of the scalenus anterior muscle by Doctor Bunkley confirmed the diagnosis. The relief from pain and soreness was immediate. Recent reports indicate that he still has some tenderness in the deltoid region and moderate pain in the arm at times. This may be due to regeneration of some fibers of the scalenus anterior muscle or some unsectioned fibers.

COMMENT—The connection between traumatism and the scalenus anterior syndrome is rather convincing in this case. The results of the operation are additional proof of the theory. This case illustrates the traumatic etiology due to indirect injury to the scalenus anterior muscle. While there was a cervical rib present, it produced no pressure upon the brachial plexus until the injury to the shoulder and the section of the scalenus anterior muscle gave immediate and permanent relief. This patient is a physician and he had observed the progress of the symptomatology from the beginning of his ailment. There were no vascular symptoms. The traumatism in this case, as in all of the others, was not directly to the scalenus anterior muscle although it must have caused violent stretching and consequent fibrous tissue formation and contraction within the muscle fibers. The theories of Todd,⁴⁵ Jones,⁴³ and others based, as they are, upon embryologic defects, if true, offer a clue to the disturbance caused by injury to the scalenus anterior muscle. As long as the scalenus anterior muscle could perform its normal function, even though the plexus was postfixed or anteiofixed, or the shoulder was lowered and the area covering the apex of the lung was contracted, there would be no symptoms of scalenus anterior compression. But, in these embryologically defective patients, a slight change in the normal relationship in the region of the plexus or the subclavian artery as it passes through this space or over the cervical or normal rib, would produce compression and symptoms of nerve injury, or vascular compression would arise.

Case 4—*The Neurologic Type* A housewife, age 35, mother of two children, always very nervous, had had a tonsillectomy, and a supravaginal hysterectomy for tumors, but never any serious, acute illness. A sufferer from serious periodic headaches, she was in a car wreck two years ago which threw her head violently backwards and left her with soreness in the neck, right shoulder and arm. These symptoms improved, but she remained very nervous and highly emotional. She has had, during the years, many examinations, including spinal puncture and other neurologic procedures. In December, 1937, about one year after the accident, she began to have severe headaches localized in the occipital region, diffusing over the head, and into the right side of the neck, during which she would be nauseated and would vomit. She had no fever. Shortly thereafter, she began to have severe pain in the right side of the neck, in the right shoulder, and in

the arm, but more intense on the inner side along the distribution of the ulnar nerve, with acute skin tenderness. At times, there was numbness of the fingers and hand. She did not have constant pain in the right arm, but she did have a number of similar spells frequently during the next two years. She was employed as a bookkeeper and tried to continue, but the pain in the right arm and the hand prevented. About one month before examination an attack came on which has not subsided. She has, also, pain in the left side of the head and some left cervical tenderness when the headaches are most severe or continue for any length of time.



FIG 3—Case 1. Roentgenogram showing a well developed right cervical rib which does not articulate with the first rib—this is very indistinct in this reproduction but is readily identified in the original roentgenogram.

Examination disclosed bilateral cervical ribs with definite arthritis of the cervical spine (Fig 3). A few days later, she had an acute attack of severe pain in the occipital region, radiating into the right side of the neck, into the right arm and forearm and hand, the distribution of the ulnar nerve was definitely and directly affected, although she complained of pain in the entire arm, it was mild and not definitely defined as was the ulnar pain. There was no skin anesthesia or paresthesia. Predicated upon this history and examination it was believed that there was sufficient evidence of pressure upon the lowest nerve trunk to justify an operation. The scalenus anterior muscle was sectioned with relief of all of the symptoms referred to the distribution of the ulnar nerve.

Subsequent Course—She did quite well for some time, but the spells of severe occipital headache returned with both greater intensity and frequency, with extension of the spinal pain to the thoracic region. She was treated by another physician for this with a plaster spinal splint, rest in bed for weeks and liberal use of endocrine drugs. She was not benefited. Recent studies show that there has been a marked extension of the cervical and dorsal spinal arthritis. The operation of sectioning the scalenus anterior succeeded in relieving the ulnar compression, but the operation was ill advised and should not have been performed. The spinal arthritis was not taken sufficiently

into consideration at the time of the operation. The cervical rib was not removed but it is doubtful that its removal would have changed the results.

Comment—This case involves more than scalenus anterior syndrome, it was a combination of several pathologic entities and should not have been operated upon. It, however, illustrates another type of pathology and symptomatology different from the others, although the history of traumatism is associated with multiple others, symptomatology from which pathologic con-

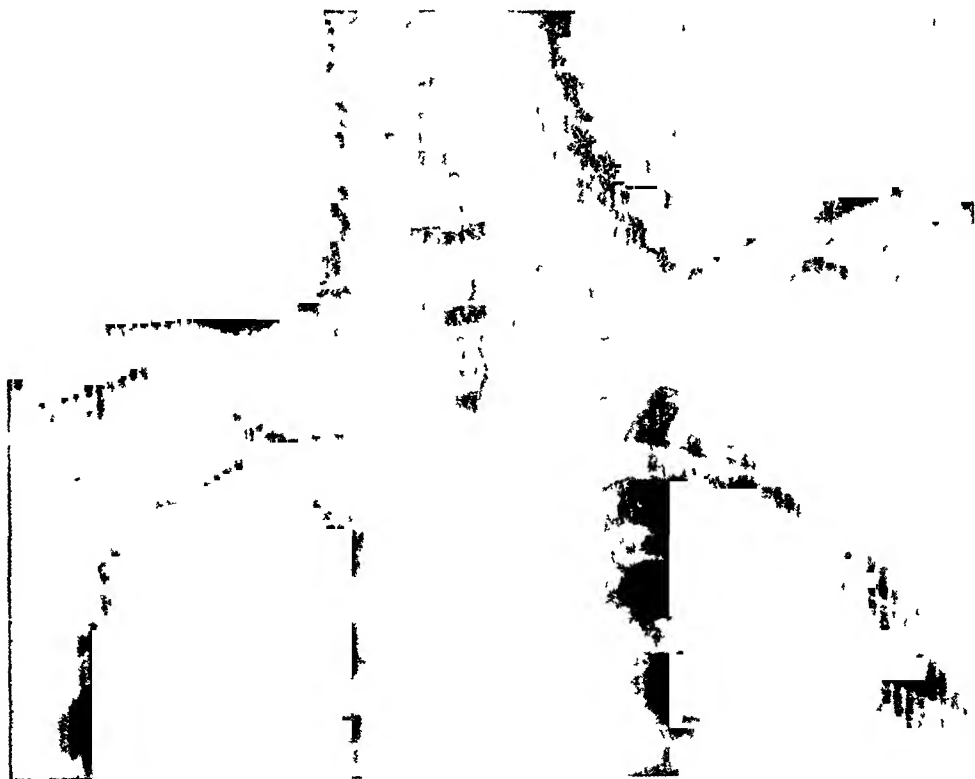


FIG 4—*Case 1*. Roentgenogram showing bilateral cervical ribs, neither of which articulates with the first rib. The one on the right is the larger, and extends almost to the rib.

ditions she is still suffering. This case should be classed as a failure although the symptoms for which the operation was done were relieved.

CASES ILLUSTRATING MINOR DEGREES OF NEUROLOGIC AND VASCULAR COMPRESSION

Case 1—A farmer, age 56, accustomed to drive a tractor, began to suffer from indefinite pains in the right arm and forearm. The pain was felt most in the medial side of the arm down to the hand and in the little and ring fingers, which were numb at times and stiff. He complained of not being able to use the hand and arm as he had formerly. There was an indefinite but constant pain in the shoulder and in the supraclavicular fossa. He continued to drive the tractor, but the pain became more severe and he sought relief from the discomfort. There were no changes in the skin reactions and no differences in temperature or pulse. When the head was held backwards and to the right, the pain was more acute, but there was no change in the pulse. Roentgenologic examination showed bilateral cervical ribs, the one on the right was the longer, but did not articulate with the first rib (Fig 4). This was diagnosed as a mild degree of the lowest cervical trunk compression against the cervical rib, caused by dragging the shoulder downwards when driving a tractor. He was directed to drive the tractor

more carefully, to keep the shoulders held higher, and to sit erect when at work. He soon recovered from the pain. But, later, when he did not observe these precautions, the pain returned.

Case 2—A woman, age 55, housewife, about five years ago began to suffer, at intervals, from a painful left shoulder, there were pain and stiffness in the arm, especially after much use of the limb. She slept on the right side because of pain when lying on the left. About four weeks ago, she began to have severe pain and numbness in the outer side of the arm and in the thumb, and second and third fingers, the fingers gradually became very numb and useless. Later the entire hand became numb and so stiff that she could not use it. She felt most comfortable with the arm held high over the chest and the shoulders backwards. When the pain became very severe, she had to sleep on her back. She now holds the arm pronated across the abdomen and complains of constant pain in it. Blood pressure in the right arm 220/130, in the left it could not be taken because of the pain and immediate swelling when the band was applied, however, the pulse is equal at the wrist and it is not affected in the left arm by turning the head to the left side. The whole outer side of the left arm is very tender, but there is no edema. There is a firm, resistant, nonpulsatile mass in the left supraclavicular fossa, the region of the scalenus anterior muscle is firm, enlarged as compared to the other side and very tender. Coordinated movements in both arms are equal, except for retardation in the left due to pain on any attempt to move it. The neurologic details will not be related here, but there were slight changes in the outer side of the left arm and fingers.

Roentgenologic examination shows that there is a marked cervical arthritis, that the transverse process of the seventh cervical vertebra is longer than normal, that there are no cervical ribs, but there is decalcification of the bones of the left shoulder joint. This is clearly a case of neuritis due to compression of the middle and upper nerve trunks without affecting the lowest trunk. The extreme pain when the cuff is used to determine the blood pressure is due to the tenderness of the muscles of the upper arm.

Case 3—A male, age 21, farmer, began about ten years ago to have pain in the left shoulder and later in the arm following heavy farm work. The pain ranged down the outer side of the arm to the elbow, he has had spells of pain ever since, much worse when he uses the arm, he has not had swelling or edema of the arm or hand, but he has had tingling in all of the fingers except the thumb, especially after doing any hard labor which requires use of the left arm. The shoulder and arm have shrunk considerably, probably due to nonuse, as he has failed to use the arm for several years because of intense pain when he exercised it. The left shoulder is lower than the right. This is a case due to dropping of the shoulder. There are no changes in the pulse, pressure or volume in change of position in the arm. The roentgenogram showed a long, left cervical rib. He refused operation. He claims to have improved under postural and medical treatment.

Comment—This case is interesting because of the absence of vascular symptoms, the symptoms are neurologic and have resulted in pain on use, loss of function of the arm and atrophy of the muscles. The pressure evidently does not affect the lowest trunk or there would probably be stimulation of the sympathetic and vasomotor nerves producing vascular changes.

REPORTS OF MILD NEUROLOGIC CASES

Postural and Age Defects

Case 1—A female, age 54, who had never done any real labor, began to suffer from pain along the distribution of both ulnar nerves, which gradually increased in intensity until she was disabled. She became weak, listless, stoop-shouldered, etc. Roentgenograms showed bilateral ribs (Fig 5). Tenotomy of both scalenus anterior

THE CERVICOBRACHIAL SYNDROME



FIG 5—*Case 1* Roentgenogram showing bilateral cervical ribs, well developed, the one on the right side articulates with the first rib while that on the left side is almost in contact with the first rib

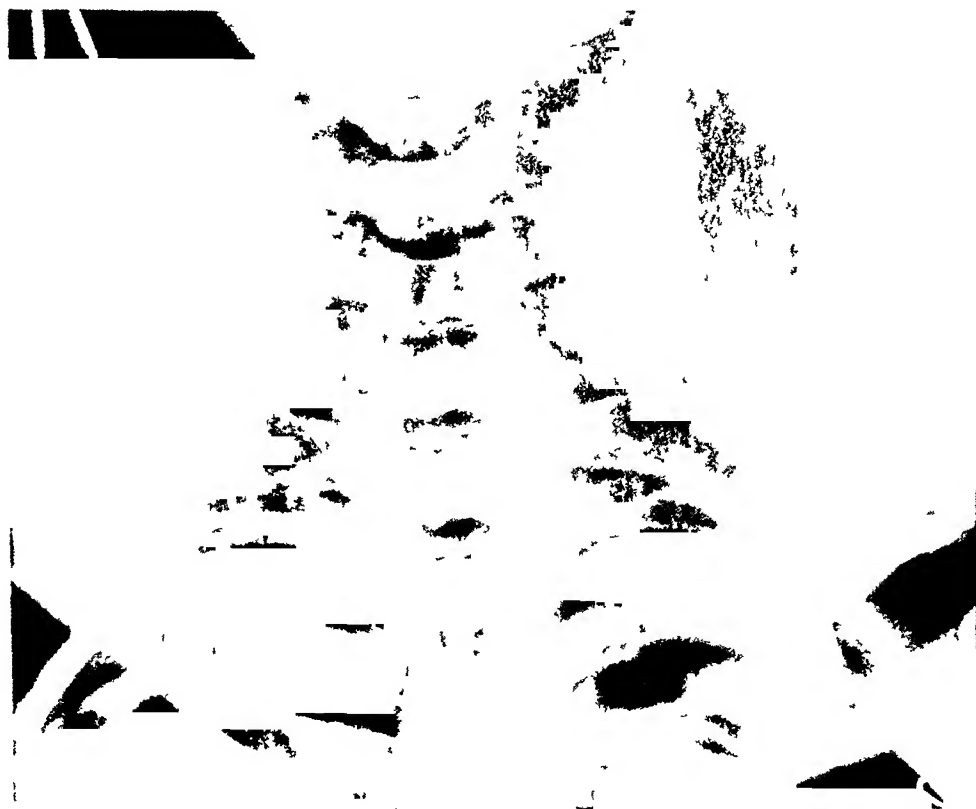


FIG 6—*Case 2* Roentgenogram showing bilateral cervical ribs, well developed, but which do not articulate with the first rib

muscles gave perfect relief. This case may be classified as both postural and age neurologic defects.

Case 2—A female, age 26, greatly debilitated, and with much loss of weight, began to suffer, especially after physical effort, from pain in the ulnar nerve distribution and coldness of both arms and hands. Roentgenograms showed bilateral cervical ribs (Fig 6). She was perfectly relieved by a change in postural habits and an increase in weight.

These two cases illustrate a type of scalenus syndrome occasionally seen in general practice.

MILD TRAUMATIC CASES

Case 1—A strong, healthy male, age 18, was wrestling when he fell on the right shoulder and suffered acute pain in the shoulder and in the side of the neck. A few



FIG 7—Case 2. Roentgenogram showing short bilateral cervical ribs, the larger one is on the right, but neither articulates with the first rib. The reproduction is rather indistinct but shows well on the original roentgenogram.

days later, he began to feel pain and numbness in the course of the ulnar nerve. Rest, hot applications, and mild faradic current were employed. In a few weeks, he was well.

Case 2—A truck driver, age 21, fell off a truck and struck the left shoulder on the pavement. Since then, he has felt numbness of the arm, tingling of the little and ring fingers, he cannot abduct or flex the forearm, the hand hangs limp and is cold. Roentgenograms disclosed short, bilateral cervical ribs (Fig 7). After the settlement of a suit, he could abduct the arm but all of the other symptoms remain.

Case 3—A female, age 28, housewife, complained of bilateral shoulder pain, numbness in the little and ring fingers following exercise or lifting, etc. Roentgenograms showed small, bilateral cervical ribs. She was relieved by rest and corrective posture.

MILD CASES DUE TO ACUTE INFECTION

Case 1—A healthy male, age 53, had a severe attack of influenza during which he suffered severe throat inflammation. A few weeks after recovery, he began to suffer

from a most distressing ulnar neuritis associated with coldness and numbness of the fourth and fifth fingers. This lasted for several months, followed by recovery. Other cases have been observed.

Classification of the Types of Cervicobachial Syndrome—The symptoms under the general heading cervicobachial syndrome may be, for purposes of study, classified into three well-defined categories, *viz*:

First, Those cases which exhibit neurologic symptoms as their major manifestation

Second, Those cases which exhibit vascular symptoms as their major manifestation

Third, Those cases which exhibit a combination of both neurologic and vascular symptoms

These three classifications are definitely separated by diagnostic criteria which are easily recognized and classified. They arise from, and are an expression of, the major pathology of the disease. The causes of these conditions are similar, but the expression of the pathologic processes is different. That is, compression of either the neurologic structures or the vascular trunks produces symptoms peculiar to their functions. It is the pathologic reaction of these two different anatomic tissues either to intermittent or to long continued pressure—in the nerve tissues it is numbness, pain, paralysis and loss of function, in the vascular structures it is moderate pain, edema, swelling, obstruction of the blood flow finally ending in clotting in the vessels and, if serious enough, death of the tissues supplied by these vessels.

This theory is very simple and clarifies the diagnostic problems. The location of the pathology is confined to a small area in the neck but one which is full of nerves and blood vessels, surrounded by muscles and osseous structures which have undergone great and vital changes in the course of evolution and embryology. Many, if not all, of the diseases in this small region are the result of developmental defects. At this juncture, a discussion of the embryology and the anatomy is necessary to an understanding of the structures involved.

Embryology of the Cervicobachial Region—There are certain regions of the spine which are called "unstable",⁴⁰ these regions lie at the junction of one section of the spine with another, *viz*: the cervicodorsal, dorsolumbar and the lumbosacral junctions. At an early stage of the development of the vertebrae all are of the same generalized type, later, the vertebrae of each body segment assume their peculiar forms but it is not unusual for one vertebra to assume some or all of the characteristics of the one above it or below it. These variations are often of clinical importance. The cervical ribs arise embryologically from centers of ossification in the anterior root of the transverse processes of the seventh, sometimes the sixth, cervical vertebra, these appear about the sixth month of fetal life. In all of the cervical ribs, except the seventh, sometimes in the sixth, the centers of ossification disappear, from this center, a rib may develop. In the higher vertebrates, such as man, there should be no cervical ribs. When the limb buds appear, they crowd out

the 11b centers, also, the development of the nerves supplying the limbs encroaches upon the 11b centers and aids the limb buds, preventing their development

At an early stage, the nerves and limb buds grow out at right angles to the vertebrae, but with the growth and increase in size, they assume a downward position as the spine lengthens upward, which increases the disproportion between the vertebrae and the nerve roots. As this descent of the nerves takes place, a conflict arises between the 11b centers and the growing nerve trunks. This theory¹³ may explain the disappearance of the cervical ribs. This region is subject to other changes in the arrangement of the sympathetic and vasomotor nerves as they are reflected downwards and are incorporated into the lower nerve trunks where they cause severe pain and other changes in function when any obstruction is pressing on the nerve trunks.

It is interesting to note that the first lumbar vertebra occasionally develops a 11b comparable with the cervical 11bs, the embryology may explain some of the painful lumbar spinal cases.

Anatomy of the Neck —Briefly stated,¹² the first rib is the shortest in the body, except the twelfth. It lies in the boundary between the neck and thorax, largely under cover of the clavicle, its posterior end is above the clavicle, and its anterior end is immediately below the clavicle. The groove for the artery is about the middle of the body, the groove for the vein is nearer the anterior end. Between the grooves for the artery and the vein is a tubercle, the scalene tubercle, to which is attached the anterior scalene muscle and to the rough area on the 11b, the surface behind the groove for the artery gives insertion to the middle scalene muscle. The greater part of the anterior ramus of the first thoracic nerve, on its way to join the brachial plexus, runs upwards and laterally in front of the neck and then lies in the posterior part of the groove for the artery, between the artery and the scalenus medius. In some cases, there is a special groove for the lodgment of the first thoracic nerve, or the lowest trunk of the brachial plexus, immediately behind the groove for the artery. The first 11b articulates with only one facet to the first thoracic vertebra.

The scalenus anterior arises from the anterior tubercles of the transverse processes of the third, fourth, fifth, and sixth cervical vertebrae and runs down laterally to attach to the scalene tubercle of the first rib in front of the subclavian artery, the scalenus medius arises from the posterior tubercles of the transverse processes of the second to the sixth cervical vertebrae. Both muscles aid in respiration, in fixing the neck, etc. They are supplied by branches which arise directly from the anterior ramus of the lowest four or five cervical nerves. Callender¹¹ says that branches from the seventh and eighth primary divisions supply the longus colli and the scaleni. When the cervical rib is more than 5 cm it displaces the subclavian artery and the brachial plexus upwards.

If the chest is lengthened by a cervical 11b, there is a higher arch and a sharper curve in the subclavian artery. Unless the 11b is well developed, it is

too short to support the artery, and may be crossed only by the lower trunk of the brachial plexus. The most frequent results are the nerve phenomena referred to the arm and hand due to pressure on the lower trunk which is composed of the eighth cervical and first thoracic nerves which supply the inner side of the hand and arm.

THEORIES OF THE ETIOLOGY OF THE CERVICOBACHIAL SYNDROME

(1) Compression of the nerve trunks as they pass between the scalenus anterior and the scalenus medius.

(2) Injury to the nerve trunks and the subclavian artery as they cross the normal rib or a cervical rib, or are obstructed between clavicle and normal or cervical rib.

(3) Injuries to the sympathetic and the vasomotor nerves supplying the subclavian artery by the scalenus anterior, or cervical rib, producing vascular damage.

(4) Traumatism, direct or indirect, of the scalenus anterior muscle resulting in fibrosis and contraction, which compress the nerve trunks and the subclavian artery.

(5) Embryologic defects which alter the course of the nerve trunks in relation to the scalene muscles and normal or cervical ribs.

(6) Postural or functional defects, such as dropping of the shoulder girdle, due to ill health, faulty postural habits, occupational and vocational habits, advanced age, *etc*.

(7) Narrowing of the upper thoracic cap as a result of adjacent infections or anatomic defects.

(8) Acute infections producing myositis.

(9) Intermittent traumatism to the subclavian artery by cervical rib or normal rib, due to normal movements of the shoulder joint.

Discussion—The recent literature has numerous reports of cases presenting the typical scalenus syndrome without either a cervical rib or a compressing first rib, the cause of the symptoms seems to be limited to contraction of the scalenus anterior muscle. Naffziger³⁰ reports 18 cases presenting symptoms of scalenus syndrome, 12 of which had no cervical ribs and six had very small ribs present but they were not observed at operation. Tenotomy of the scalenus anterior muscle gave relief of all of them. The relief in a few was delayed for several months. In this report, no mention was made of the condition of the cervical spine as to the presence of arthritis or other conditions which have been reported as possible etiologic factors. MacDermott²⁰ remarks that a normal first rib may produce all of the symptoms of a cervical rib, Flothow²¹ reports two cases without cervical ribs, one with a "nubbin" of a first rib, Edington¹³ likewise reports one case without cervical rib or any other protuberance which might cause compression, he cites cases from the literature (Murphy, Moiley, Wood, Jones, Stopford,⁴⁸ Wingate Todd and Telford and Stopford). Haven,²³ also, cites two cases from the Mason Clinic which presented the symptoms of scalenus syndrome with normal first ribs.

and no cervical ribs. Many others could be quoted from the recent literature.

These observations would suggest that there is something besides bony malformations and anatomic defects which may be the underlying cause of the symptoms. Operative success has demonstrated the relief which comes from section of the scalenus anterior muscle, but that does not postulate a cause of the pathologic condition of the muscle involved, it merely states the results of a pathologic condition without defining or explaining its etiology. What the etiology of scalenus anterior spasm is may be surmised from a variety of causes which have been suggested.

If scalenus spasm has been associated with cervical rib, normal rib, fibrous tissue formation in the surrounding tissues, with or without injury to the shoulder, following acute illness, *etc*, there must be some definite, basic irritation acting upon the muscle which, under a multitude of influences, becomes spastic, constantly or intermittently, and produces neuritis or vascular occlusion in some degree which may be explained by presupposing damage to the nerve supply. In the pure cervical rib cases, constant and prolonged pressure upon either the nerve trunks or their sympathetic and vasomotor fibers or upon the vessel walls and, also, their nerve fibers, seems to produce all of the symptoms of scalenus syndrome. Todd¹⁵ was among the first to advocate the theory of nervous disturbances due to embryologic defects as the cause of the arterial symptoms as well as the nervous origin of the neurologic reactions. The nerve supply¹¹ of the scalenus anterior comes from the two lowest nerve trunks which are the ones most compressed, this may explain the tension of the scalenus muscle. Telford and Stopford¹⁰ support the same opinion as to the neurologic origin of the vascular symptoms. In 1914, Halsted showed experimentally that the aneurysmal dilation of an artery is distal to the constricting agent, this explains why aneurysm of the subclavian artery is distal to the cervical or normal first rib.

RESUME

This paper records a series of case reports with a partial review of the literature. Twenty cases are reported which have been examined by the writer. Traumatism is emphasized as an etiologic factor in approximately 80 per cent of them. Twelve cases were operated upon with satisfactory results except one case which was unsuitable for tenotomy of the anterior scalene muscle.

A review of the current literature convinces one that the nomenclature should be simplified upon an anatomic or pathologic basis so that it will describe and define the symptomatology more accurately. The review further shows that there are many different pathologic conditions in the small area of the neck which are due to only a few anatomic structures which have become abnormal in their functions. These are the scalene muscles, cervical ribs, normal first thoracic ribs, the clavicle, the cervical nerve trunks, the subclavian artery, and the sympathetic and vasomotor nerves.

The symptoms of disease of the structures are either those of neuritis or

vascular pathology The area of disease is limited to the hands, arms, shoulders, side of the neck and side of the head, they are either vascular, neurologic or both combined In order to simplify the nomenclature and to express a more correct symptomatology, the term "cervicobachial syndrome" is suggested

BIBLIOGRAPHY

- ¹ Patterson, Russel H Surgery for Cervical Ribs ANNALS OF SURGERY, 102, No 6, 972-979, December, 1935
- ² Riches, E W The Anatomy of Cervical Rib With a Report of a Case Brit Jour Surg, 16, 235-238, October, 1928
- ³ Pfeiffer, George E Cervical Rib with Excision U S Vet Med Bull, 5, 898-901, November, 1929
- ⁴ Cervical Rib with Vascular Complications (With Special Plate) Brit Med Jour, 1, 782-783, May 6, 1933
- ⁵ Kasman, Louis P, and Bernstein, William Cervical Ribs Am Jour Surg, 30, 372-375, November, 1935
- ⁶ Rubin, Lionel C and Cipollaro, Anthony C Onychodystrophy Caused by Cervical Rib Arch Derm and Syph, 39, 430-433, March, 1939
- ⁷ Wilbour, L S Cervical Rib Jour Okla S Med Assn, 23, 106-108, April, 1930
- ⁸ Cervical Rib and Scalenus Anticus Syndrome J A M A, 109, 877-878, September 11, 1937
- ⁹ Lindskog, G E, and Howes, E L Cervical Rib Associated with Aneurysm of the Subclavian Artery Arch Surg, 34, 310-319, February, 1937
- ¹⁰ Telford, E D, and Stopford, John S B The Vascular Complications of Cervical Rib Brit Jour Surg, 18, 557-564, April 1931
- ¹¹ Oljenick, Ignaz Bilateral Cervical Rib, Clinical and Experimental Observations on a Case Arch Surg, 18, 1984-2007, April, 1929
- ¹² Davis, David Bennett, and King, J Cash Cervical Rib in Early Life Amer Jour Dis Child, 56, 744-755, October, 1938
- ¹³ Edington, G H Cervical Ribs Glasgow Med Jour, 118, 289-313, November, 1932
- ¹⁴ Robinson, S, Stone, C S, Jr, and Elliot, A H Cervical Ribs Western Jour Surg, Obstet and Gynec, 43, No 6, 295-304, June, 1935
- ¹⁵ Arostegui, Gonzalo E Supernumerary Cervical Rib Jour Mt Sinai Hosp, 4, 189-197, November-December, 1937
- ¹⁶ Adson, Alfred W Cervical Rib Atlantic Med Jour, 31, 222-232, January, 1928
- ¹⁷ Collins, Clifford, U Cervical Ribs Am Jour Surg, 14, No 2, 449-451, November, 1931
- ¹⁸ Von Klimko, V Beitr z klin Chir, Bruns', 168 Bd, Heft 1, July 13, 1938
- ¹⁹ Baumgartner, A, Clerc, A, and Macrez, C Les Côtes Cervicales Presse Med, 46 Année, 91, November 12, 1938
- ²⁰ MacDermott, E N Tenotomy of the Scalenus Anticus, A Substitute for Resection of a Cervical Rib, with Report of a Case Irish Jour Med Sci, Sixth Series, 98, 81-88, February, 1934
- ²¹ Flothow, Paul G Cervical Rib and the Anterior Scalenus Syndrome Western Jour Surg, Obstet and Gynec, 44, No 10, 571-573, October, 1936
- ²² Adson, A W, and Allen, E V Proc Staff Meet Mayo Clinic, 13, No 40, 637-640, October 5, 1938, Vascular Clinics VI Thrombosis of Arteries of the Right Upper Extremity Resulting from Anomalous First Rib
- ²³ Haven, Hale Neurocirculatory Scalenus Anticus Syndrome in the Presence of Developmental Defects of the First Rib Yale Jour Biol and Med, 11, No 5, 443-445, May, 1939

- ²⁴ Adson, A W Surgical Treatment of Cervical Ribs Tex S Jour Med, 28, 739, March, 1933
- ²⁵ Adson, A W, and Coffey, J R Cervical Rib, A Method of Anterior Approach for Relief of Symptoms by Division of the Scalenus Anticus ANNALS OF SURGERY, 85, 839, June, 1927
- ²⁶ Boorstein, S W Cervical Rib, with a Report of Six Cases, One Operative Jour Bone and Joint Surg, 4, No 4, 687-704, 1922
- ²⁷ Carroll, W C Cervical Ribs and Abnormal First Thoracic Ribs Minnesota Med, 15, 828, December, 1932
- ²⁸ Collins, C U Cervical Ribs Am Jour Surg, 14, 449, November, 1931
- ²⁹ Craig, W McK, and Nepper, P A Cervical Rib and the Scalenus Anticus Syndrome ANNAIS OF SURGERY, 105, 556, April, 1937
- ³⁰ Gage, M Scalenus Anticus Syndrome Surgerv, 5, 599, April, 1939
- ³¹ Honeij, J A Cervical Ribs, With Presentation of Cases and a Bibliography Surg, Gynec and Obstet, 30, 481, 1920
- ³² Klemberg, S, and Levine, M A Headache as a Symptom of Cervical Rib ANNALS OF SURGERY, 105, 299, February, 1937
- ³³ McKenna, C H A Report on Two Cases of Cervical Rib and An Operative Measure to Prevent Recurrence of Symptoms Surg, Gynec and Obstet, 16, 322, 1913
- ³⁴ Morris, C H Syringomelia Associated with Cervical Ribs, J A M A, 78, 109, 1922
- ³⁵ Ochsner, A, Gage, M, and DeBakey, M Scalenus Anticus (Naffziger) Syndrome Am Jour Surg, 28, 669, June, 1935
- ³⁶ Plummer, S C Two Cases of Operative Removal of Cervical Ribs Surg, Gynec and Obstet, 10, 321, 1910
- ³⁷ Rao, N M, and Rao, L M Two Cases of Bilateral Cervical Ribs Indian Med Gaz, 69, 689, December, 1934
- ³⁸ Reid, W D Pressure on the Brachial Plexus Causing Simulation of Coronary Disease J A M A, 110, 1724, May 21, 1938
- ³⁹ Naffziger, H C, and Grant, W T Neuritis of the Brachial Plexus Mechanical in Origin, The Scalenus Syndrome Surg, Gynec and Obstet, 67, 722, 1938
- ⁴⁰ Keith, Sir Arthur Human Embryology and Morphology 5th Ed, Wm Wood & Co, Baltimore, 1933
- ⁴¹ Callender, C Latimer Surgical Anatomy W B Saunders Co, Philadelphia, 1933
- ⁴² Cunningham, D J A Text-Book of Anatomy 5th Ed, Wm Wood & Co, New York, 1923
- ⁴³ Jones, F W The Anatomy of Cervical Ribs, Proc Roy Soc Med, 6, Part 1 (Clin Sect), 95, 1912-1913
- ⁴⁴ Murphy, J B The Clinical Significance of Cervical Ribs Surg, Gynec and Obstet, 3, 514, 1906
- ⁴⁵ Todd, T W The Descent of the Shoulder after Birth Its Significance in the Production of Pressure-Symptoms on the Lower Brachial Trunk Anat Anzeiger, 41, 385, 1912
- ⁴⁶ Hill, R M Vascular Anomalies of the Upper Limbs Associated with Cervical Ribs Report of a Case and Review of the Literature Brit Jour Surg, 27, 105, 1939
- ⁴⁷ Eden, Kenneth C The Vascular Complications of Cervical Ribs and First Thoracic Rib Abnormalities Brit Jour Surg, 27, 105, 1939
- ⁴⁸ Stopford, John S B Gunshot Injuries of the Cervical Nerve Roots Lancet, 1, 336-338, March 1, 1919

DISCUSSION —DR MIMS GAGE (New Orleans, La) I have enjoyed the presentation of both Doctors Donald and Aynesworth, and especially that part which dealt with etiology and diagnosis In the Surgical Clinic at Tulane, we have been interested in the study of the scalenus anticus syndrome for some

time In 1934, we presented the two prevailing theories (1) Todd's failure of descent of the shoulder girdle, and (2) Jones' low origin of the brachial plexus To these two we added "spasm of the scalenus muscle" The latter we believed to be responsible for the persistence of this most interesting clinical entity I was able to confirm that spasm of the muscle was responsible for the persistence of the symptoms by blocking the scalenus anticus muscle with 1 per cent novocain This resulted in relief of the symptoms for varying periods of time (longest, ten hours) In two cases of cervical rib and three cases of scalenus anticus syndrome without cervical rib, there was temporary relief of symptoms, which is suggestive that spasm is responsible for the persistence of symptoms Therefore, I have been quite interested in trying to discover the etiologic factor or factors responsible for the spasm of the scalenus anticus

In conjunction with Doctors Reed and Weed of the Department of Gross Anatomy, a study is now being made of the scalenus anticus muscle, its origin and variations in attachment To our surprise, we have found that there exists a scalenus anticus major and minor in a number of the subjects, the brachial plexus and subclavian artery passing between the scalenus major and minor in all cases in which this condition has been found To date, 27 cadavers have been dissected and we have found eight instances of scalenus anticus major and minor This anomaly was found bilaterally five times, and was unilateral in three, two on the left and one on the right side In two instances the brachial plexus was found to pass through the fibers of the scalenus anticus muscle These findings may have a direct bearing upon the etiology of the scalenus anticus syndrome It will be of interest in all future operations performed for the relief of this interesting clinical entity to thoroughly investigate the brachial plexus and scalenus anticus muscle and report all anomalies found in this anatomic area We should determine the presence or absence of the scalenus anticus major and minor as well as the passage of the brachial plexus through the above muscle

DR LUCIAN H LANDRY (New Orleans, La) It would seem that there might be some misleading elements in the diagnosis of cervical rib I am reminded of this by four cases which were sent to the service of Doctor Matas with a diagnosis of subclavian aneurysm, simply because the subclavian artery was displaced or elevated by a cervical rib and produced pulsation in the supraclavicular space

We did have one case of cervical rib in a woman who fell down a stairway on shipboard, and the trauma, plus the preexisting cervical rib, was instrumental in producing a subclavian aneurysm

DR ALTON OCHSNER (New Orleans, La) In addition to the diagnostic test which Doctor Gage has described, I should like to call attention to a procedure which we feel is of value in cases of scalenus anticus syndrome, and which can be simply performed If the scalenus anticus muscle is put under tension, the symptoms are likely to be aggravated and there is a likelihood of compression of the subclavian artery which can be detected by a diminution in pulse by such a maneuver As the scalenus anticus takes origin from the transverse processes of the upper cervical vertebrae, if the patient will extend his head and turn the face toward the affected side, thus throwing the attachment of the scalenus anticus backward and rotating the vertebrae to increase the tension of the scalenus anticus, one can make observations concerning the pulse This can be detected either by palpating the pulse or, graphically, by means of oscillometriograms taken before and after turning of the head

Because of a recurrence which we had in one case following simple division of the muscle, we believe that myotomy is not sufficient in cases of scalenus anticus syndrome but that an excision of a portion of the muscle should be performed in order to prevent bridging of the gap by scar tissue and recurrence of symptoms.

As Doctor Gage stated, we have found, invariably, definite hypertrophy of the muscle, which is probably the result of its continued stimulation. We believe that a vicious circle is set up, as a result of constriction of the muscle there is an irritation of the brachial plexus which in turn causes contraction of the muscle and aggravates the condition. It was interesting to me that in Doctor Donald's patients the most frequent occurrence was on the left side. In our experience the right side is usually involved in right-handed people. Even with cervical ribs which are more likely to be on the left than on the right the symptoms are more likely to be on the right side. It is more frequent in women and is likely to be aggravated by such motions as sweeping.

DR K. H. AYNESWORTH (Waco, Tex., in closing) There is not much to add except to mention that there was a history of traumatism in all cases except four. Frequently the trauma is from driving a tractor. If you have seen these in action, you know how they go over rough plowed ground and how the shoulders are subjected to possible injury. Some of my patients have had to stop driving tractors to get relief. I devised a figure-of-eight bandage, and when they wore this they could drive, but if they left it off the pain returned. I am not able to distinguish between trauma and other causes, but if you relieve the trauma you relieve the pain. It occurs to me that trauma plays a definite rôle in the causation of the scalene syndrome. The patient loses weight and you have this dropping of the shoulders. I am not yet ready to accept the theory that the scalenus disease is the sole cause of this syndrome. I look upon the constricted muscle as a result of injury to the nerves, and knowing the pathway of the nerve supply makes this theory most logical. We know that the cervical spine and the sacrococcygeal spine have lost their ribs and have a highly developed nerve supply which is greatly interfered with in subsequent development of these structures. I strongly suspect that many cases of lumbago may be explained on the same embryologic or neurologic basis.

PARTIAL GASTRECTOMY*

A CONSIDERATION OF CERTAIN TECHNICAL PROBLEMS

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PARTIAL GASTRECTOMY is the operation of choice for intractable duodenal and gastric ulcers. This opinion is shared by all surgeons who have had an extensive personal experience with the procedure, and it is encouraging to find that the greatest number of enthusiasts are included among those who have had the most experience. The reason for this trend of thought is twofold, for the present mortality of 5 per cent following partial gastrectomy in competent hands is not greater than that following the more limited operations, and the end-results are infinitely better, because extensive removal of diseased gastric mucosa leads to a lessened incidence of gastrojejunal ulceration. The operation of partial gastrectomy is usually a straightforward procedure, the performance of which presents no problem to the well-trained surgeon possessed of an intimate knowledge of the anatomy of the upper abdomen. However, an operation of this magnitude is not infrequently fraught with technical difficulties which may tax the skill of the most ingenious operator. It is in circumstances like these that experience counts. In our own hands a mortality rate of 10 per cent for a 15-year period has been reduced to 5 per cent during the past five years, and in the last 53 consecutive partial gastrectomies for ulcer, there has been but one death. We attribute this lowered mortality in part, at least, to an increasing familiarity with the condition which has resulted in the adoption of what we believe to be improvements in our technic.

The essential steps of the operation are so well standardized that detailed reference to them is unnecessary. We will, therefore, confine the discussion to those technical points which we consider to be of major importance.

Preparation of the Patient for Operation—Patients about to be submitted to partial gastrectomy must be put in the best possible physical condition. The hemoglobin should be brought to at least 70 per cent, by blood transfusions if necessary. Dental prophylaxis is an essential part of the preparation because of the necessary postoperative period of fasting. On no account should operation be undertaken in the presence of respiratory tract irritation, and surgical procedure should be postponed for at least six weeks following even mild upper respiratory infections, since pulmonary complications following gastrectomy are always serious. The stomach is washed repeatedly with bicarbonate of soda solution during the two days previous to operation. Just

* Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

before the patient is sent to the operating room, a final lavage is given with half strength hexyl-chloro-meta-cresol, an antiseptic solution with a high phenol coefficient and low toxicity for tissue cells, developed by Dr. Frank Haitman,¹ of our staff. About 200 cc. of this solution is left in the stomach by clamping off the indwelling tube until the operation begins, when the clamp is released and the antiseptic is withdrawn with an aspirating syringe. The ordinary cleansing enema is not sufficient to clear the colon, for most of these patients have been on a low residue diet, and many of them have recently had barium. Therefore, repeated oil retention enemata and colonic lavages are necessary to cleanse the colon.

Anesthesia—Mobilization, the keynote of successful gastro-intestinal surgery, can be accomplished best only in the presence of perfect relaxation. We have found that spinal anesthesia, with nupercain administered by the Jones² method, best fulfills this requirement. Adequate anesthesia with this agent, lasting from two to three hours, is the rule rather than the exception. Thus, and freedom from systemic depression, makes nupercain stand in marked contrast to the anesthesia of uncertain height and duration so commonly obtained with other high spinal anesthetics. Seconal, gr. iii, given before the patients leave for the operating room plus a hypodermic injection of morphine sulphate, gr. $\frac{1}{4}$, given after the nupercain, insures a peaceful anesthetic period for even the most nervous patient. Blood pressure is maintained at normal levels by hypodermic injection of ephedrine, gr. $1\frac{1}{2}$, and by the routine intravenous administration of 600 cc. of 10 per cent glucose followed by 600 cc. of citrated blood, for we are convinced of the necessity of avoiding anoxia³ produced by sudden and pronounced fall in blood pressure. The good appearance of the patient at the conclusion of the operative procedure, and the excellent general condition on the following day, will convince the most skeptical of the advantage of spinal over general anesthesia. Atelectasis is just as common with the spinal anesthesia, but serious pulmonary complications are decidedly fewer.

Incision—We have continued to use the midline incision going directly through the linea alba. The skin incision either skirts to the left of the umbilicus or excises this structure completely and usually extends two inches below it to provide ample room. This method of entering the abdominal cavity has the advantages of speed, bloodlessness, and of not entering any of the fascial spaces, so that if wound infection does occur, there is minimal loss of important structures. It is important in suturing this incision to use interrupted, nonabsorbable sutures and to clear away the fatty structure of the round ligament of the liver so that the fascial edges of the linea alba can be approximated without inclusion of fat tags. In our experience, incisional hernia has not been any greater than with rectus reflecting or rectus splitting incisions.

Mobilization of the Duodenum—Mobilization of the duodenum is begun by first identifying the common duct by freeing the pylorus, after sectioning the leash of blood vessels constituting the right gastric artery. We have found

that mobilization of the pylorus and duodenum is facilitated by encircling the prepyloric area of the stomach with a ring clamp we have devised (Figs 1 and 2), which acts as a handle and enables the surgeon to apply tension

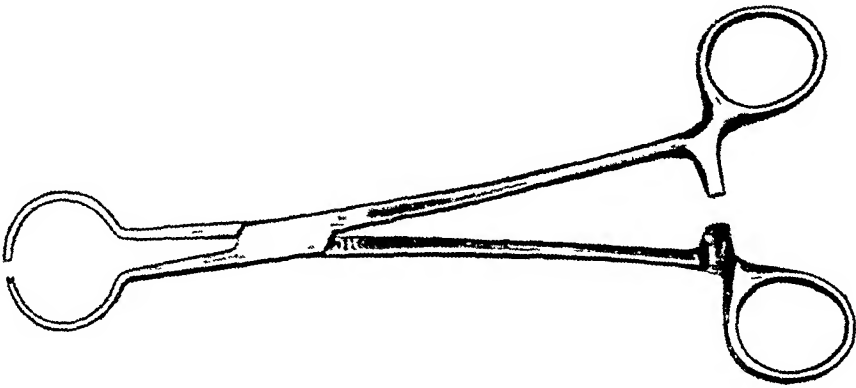


FIG 1—The ring clamp for applying traction to the duodenum

to the duodenum in the desired direction, thereby delineating the line of cleavage between the duodenum and head of the pancreas. Sharp scalpel and gauze

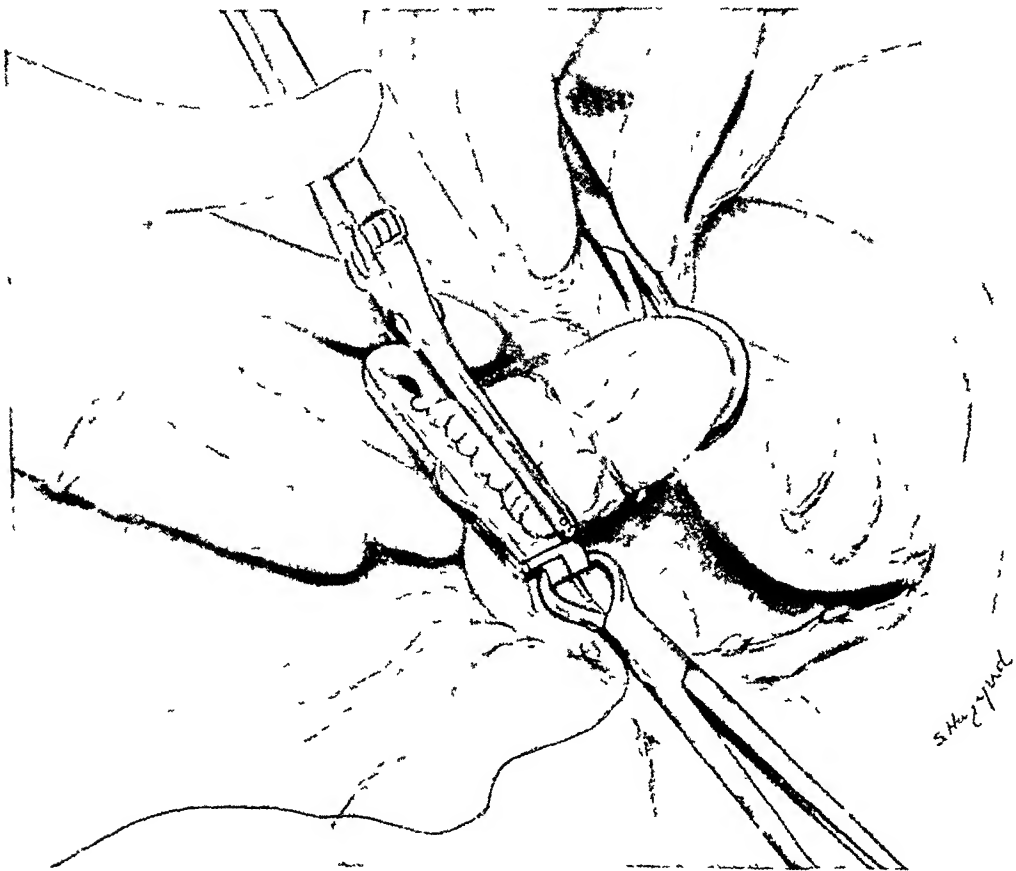


FIG 2—Duodenum just before sectioning. The McClure modification of the Furniss clamp is shown in place, with the ring clamp just proximal to the pylorus.

finger dissection will accomplish separation of the suprapapillary portion of the duodenum and the pancreas in gastric, pyloric, and nonpenetrating duodenal ulcers. However, in practice, the surgeon seldom encounters any but

penetrating ulcers, for it is just this type that resists palliative measures and eventually comes to operation. The chief danger in dealing with penetrating ulcers is of inadvertently injuring the common bile duct because of distortion of tissue from the accompanying inflammatory reaction. The best protection of the duct is obtained, of course, by identifying it before commencing the dissection and by referring to it constantly during the separation of the duodenum from the pancreas. Penetrating ulcers with small bases are usually opened into during the course of the freeing of the duodenum, and all that is necessary, then, is to continue the mobilization distal to the ulcer bed until sufficient healthy duodenum is freed to permit satisfactory closure. A minimum of 1 cm. is required. When dealing with the larger penetrating ulcers, it is best to open the anterior wall of the duodenum close to the pylorus in order to inspect the interior of the duodenum and to make certain that sufficient healthy tissue, to effect a closure, lies between the inferior margin of the ulcer and the papilla of Vater. If closure is still considered feasible, the duodenum is dissected away from the pancreas, leaving the ulcer base undisturbed. But if closure of the duodenum below the ulcer is likely to result in encroachment on the papilla of Vater, it is advisable to section the duodenum proximal to or even through the ulcer base, for experience has shown that these ulcers will cicatrize after diversion of the stomach contents. The operation then proceeds just as if the ulcer had been removed. In certain instances where the amount of inflammatory reaction surrounding the penetrating ulcer is so great that the pylorus, proximal duodenum, and pancreas appear to form a conglomerate mass, we have found that it is good practice to follow the advice of Finsterer and section the prepyloric area of the stomach¹ instead of attempting to mobilize the duodenum. The distal cut end of the stomach is closed by infolding after excising the mucosa.

Method of Sectioning the Duodenum—We prefer the Furniss clamp method, because with a minimal sacrifice of tissue, bleeding is controlled, spillage of duodenal contents is avoided, and the tied catgut suture provides an excellent medium of control for the duodenal stump. There are, however, certain instances where, in spite of maximum mobilization, the duodenum lies at such a depth in the wound that application of the standard Furniss clamp is impossible or is accomplished only with great difficulty. One of us (R. D. McC³) has devised a modification of the Furniss clamp with smaller blades and a detachable handle, thereby retaining all the advantages of the shunting principle and permitting its application where access is limited (Fig. 3). The pylorus and mobilized duodenum are steadied with the ring clamp. The modified Furniss clamp is applied to the duodenum at the proposed site of section, closed by means of its detachable handle, and then locked. A *straight intestinal needle* swedged in No. 00 chromic catgut is then inserted through the eye in the blades, thereby fixing the shirred margin of duodenum in the clamp. A Kocher or a small Payr clamp is applied proximal and close to the Furniss clamp, and the duodenum is sectioned (Fig. 4). Both cut surfaces are swabbed with antiseptic solution, and the

proximal end of the duodenum is enveloped in a gauze pad and turned over to the left

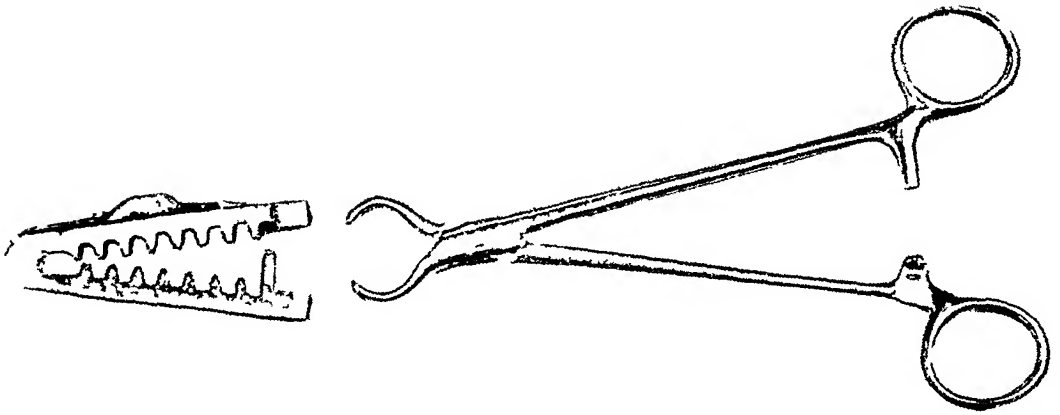


FIG 3—The modified Furniss clamp with its detachable handle

Closure of the Duodenal Stump—Closure of the duodenal stump is a most important step in the operation of partial gastrectomy, for duodenal leakage is a serious complication, and accounts for the majority of fatal issues

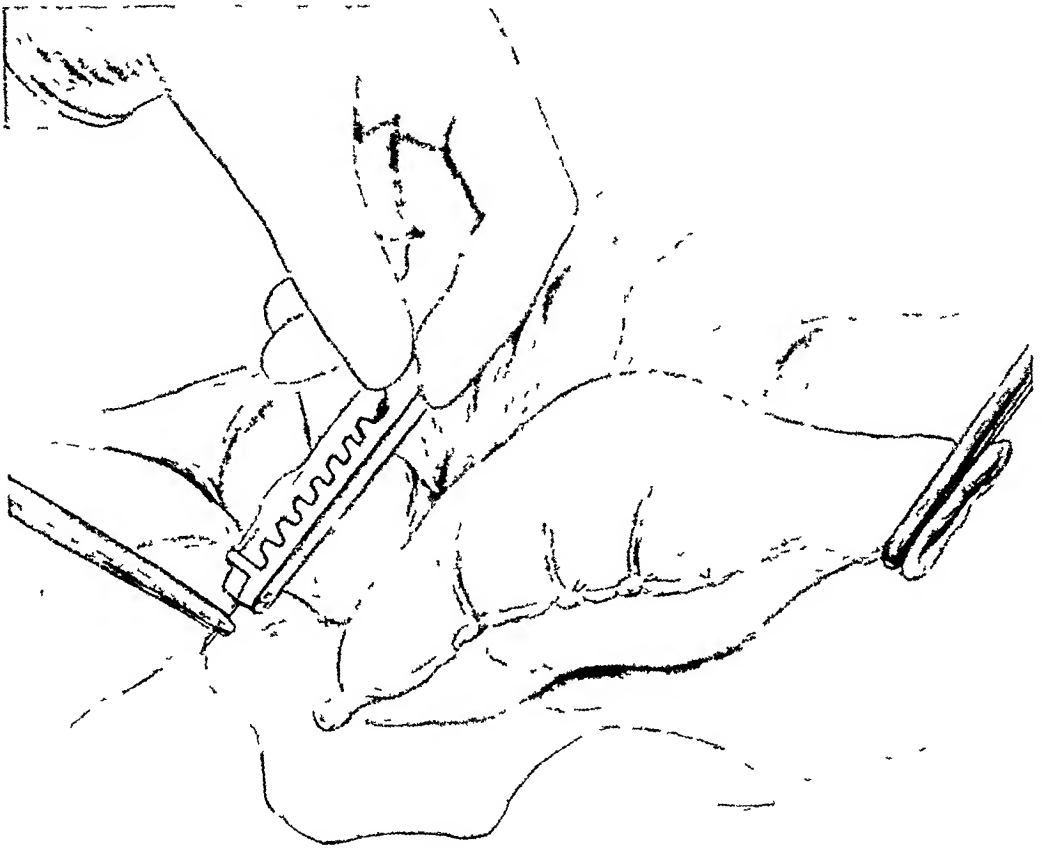


FIG 4—Duodenum after sectioning The needle is being passed through the stump of the duodenum preparatory to removing the duodenal clamp

The handle of the modified Furniss clamp is detached, and the clamp is unlocked and removed The needle previously inserted through the eye in the blade is seized at its tip and drawn through the shirred duodenal edge,

bringing with it the chromic catgut suture which is now tied, thus effectually closing the duodenum and controlling hemorrhage. The ends of the catgut are left long and used as a handle to control the duodenum until a purse-string suture of fine silk is put in the duodenal wall 2 cm from the line of section. The cut end is inverted, and the suture tightened but not tied until three or four Lembert sutures of fine silk are inserted and tied (Fig 5). We make quite a point of delaying the tying of the purse-string suture until Lembert sutures are put in and tied, for then, if the purse-string suture breaks, as not uncommonly occurs with fine silk, eversion of the cut edge



FIG 5—The closing of the duodenal stump. The purse string is being held while the interrupted silk sutures are placed.

cannot occur. The first row of Lembert sutures is reinforced at intervals and the suture line further secured with omental tags or adjacent pancreatic tissue.

Preservation of the Middle Colic Artery—Injury to the middle colic artery is an easily avoidable complication of partial gastric resection. It is always endangered when the gastrocolic omentum is sectioned, when the right gastro-epiploic artery is ligated and when the posterior gastric wall is adherent to the anterior leaf of the mesocolon, as occurs in the posterior wall of perforating gastric ulcers. Protection of the middle colic artery begins with identification of the vessel before any operative step is undertaken, continues by constant reference to its position and ends only when the opening in the transverse mesocolon is sutured to the gastric wall as the concluding step in the operation. A good practical rule to follow is not to clamp any large artery until one is certain that the vessel in question is not the middle

colic artery In sectioning the gastrocolic omentum, the lesser peritoneal cavity should be entered first and the gastric colic omentum separated from the transverse mesocolon It is well to bear in mind that the gastrocolic omentum has no vascular connection with the transverse colon, so that any structure with blood vessels entering the colon must be mesocolon and, therefore, should not be cut

Ligation of the Left Gastric Artery—Mobilization of the stomach is complete only when the left gastric artery is sectioned This vessel arises from the celiac axis and runs forward and upward toward the posterior wall of

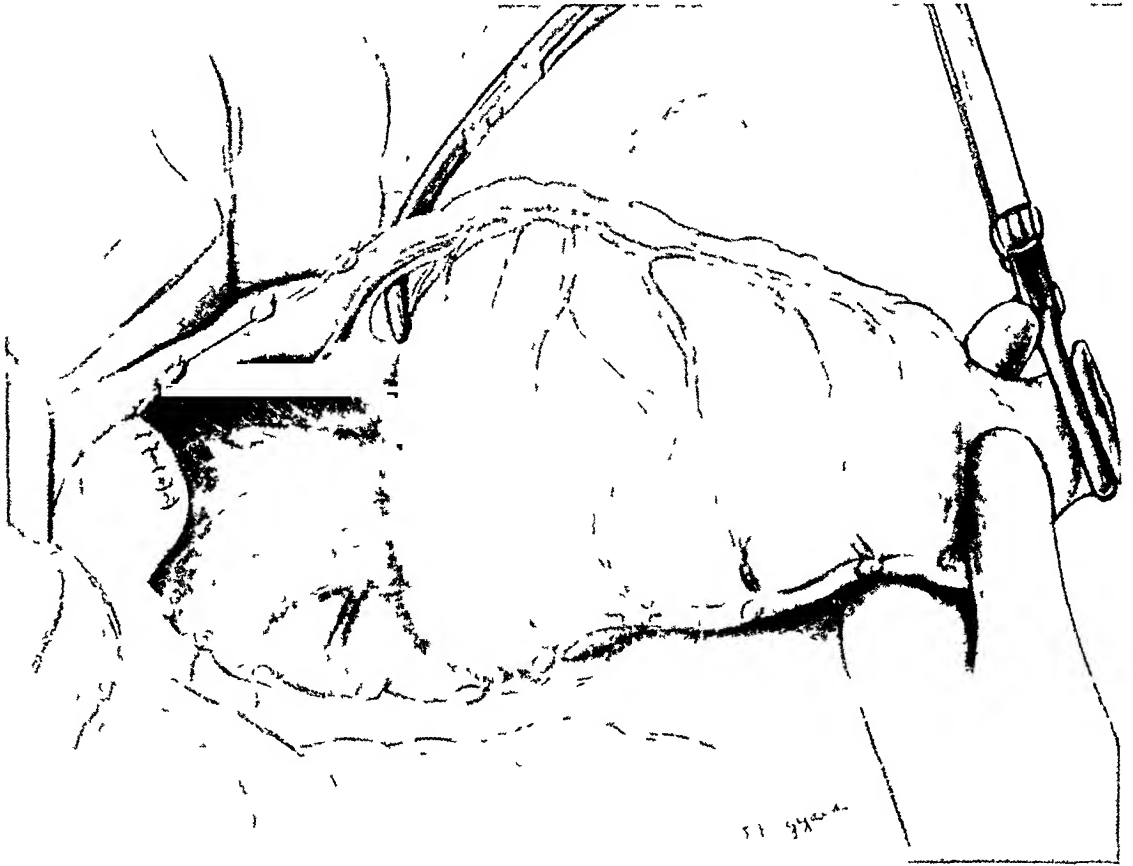


FIG 6—The isolation of the left gastric artery

the stomach in a fold of peritoneum, known as the gastropancreatic omentum⁶ Branches are supplied to the posterior wall of the stomach while the main trunk of the vessel runs toward the cardiac end of the stomach and then loops downward between the two layers of the gastrohepatic omentum where it gives off terminal branches to the lesser curvature It is obvious, therefore, that ligation of this vessel in the lesser omentum controls only a portion of the blood supply and does not effect complete mobilization of the organ We have been greatly impressed with the advantages of ligating the left gastric artery close to its origin and sectioning it together with its enveloping ligament, the gastropancreatic omentum, a structure which fixes the stomach in this region If the stomach is pulled well over to the left after severing the duodenum, the artery and its ligament stand out as a firm cord-like structure which is easily isolated and clamped (Fig 6)

Amount of Stomach Removed—In common with all who have had extensive experience with gastric resection for ulcer, we have gradually increased the amount of tissue removed until now we believe that from two-thirds to three-quarters of the stomach should be resected. Certainly, high resections do not carry any greater mortality than the more limited pylorotomies or antrectomies, and the results as indicated by our follow-up system are infinitely better. We have been impressed with the high incidence of chronic gastritis found in association with duodenal ulcer, and have

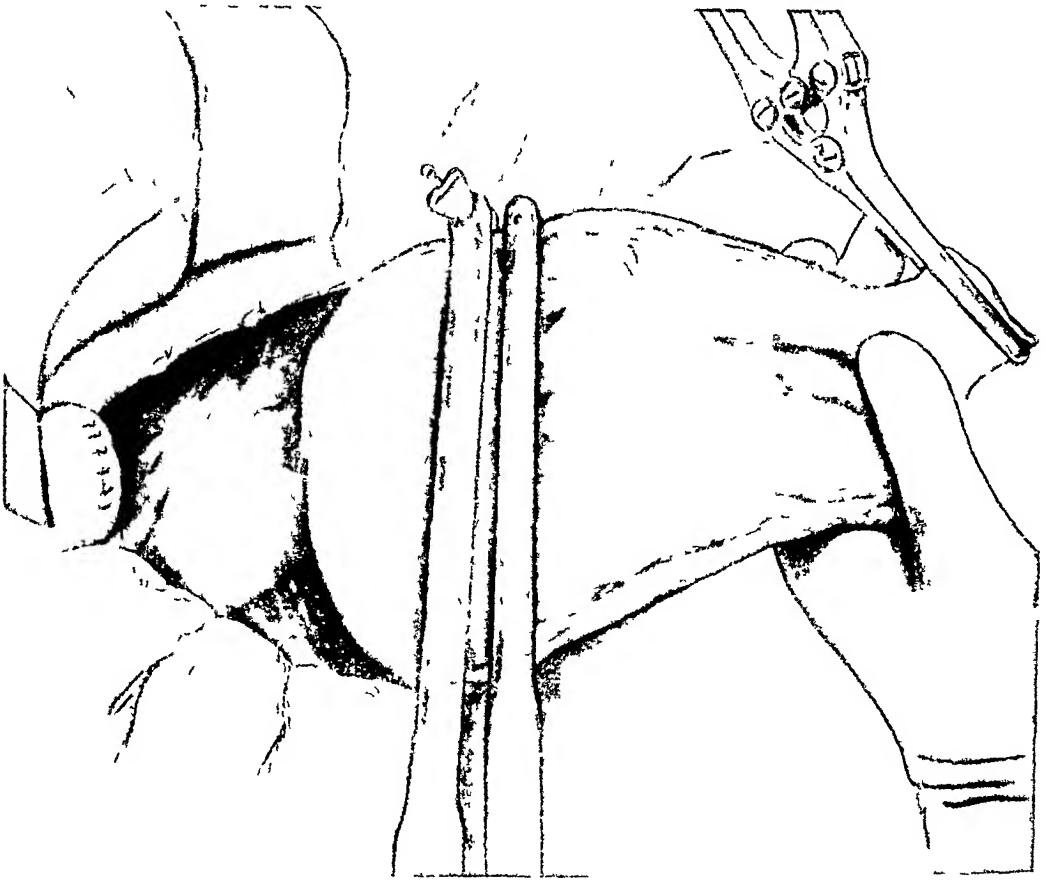


FIG 7—The large Payr clamps in place showing the wing nut on the jaws of the proximal clamp

come to believe that the excellent results following partial gastrectomy must be due in no small part to the removal of diseased gastric mucosa. The gain in weight and return of the feeling of well-being experienced by patients subsequent to operation are greater than can be accounted for by simple relief from recurring attacks of gastric distress. This opinion, stressed for many years by European surgeons,⁷ has not received the attention it deserves in this country.

We have not had any experience with the dePetz clamp but employ two large Payr crushing clamps, dividing the stomach with a scalpel between them (Fig 7). The gastric tissue protruding through the proximal clamp is then swabbed with the antiseptic hexyl-chloro-meta-cresol. To overcome slipping of the gastric wall from the Payr clamp in high resections, we have added

a hinged bar threaded with a wing-nut to the tip of the proximal clamp (Fig 8) After the clamp is closed, the extra pressure exerted by tighten-

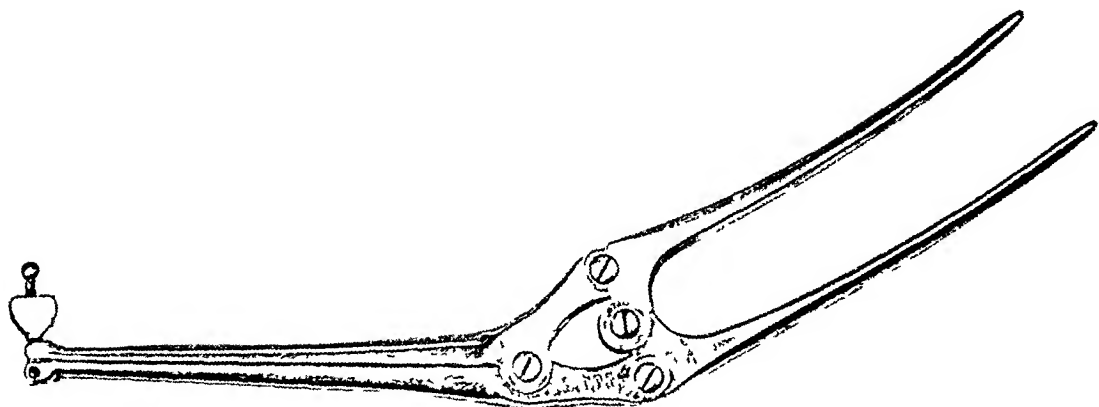


FIG 8—The huge Pavr clamp with the wing nut on the jaws

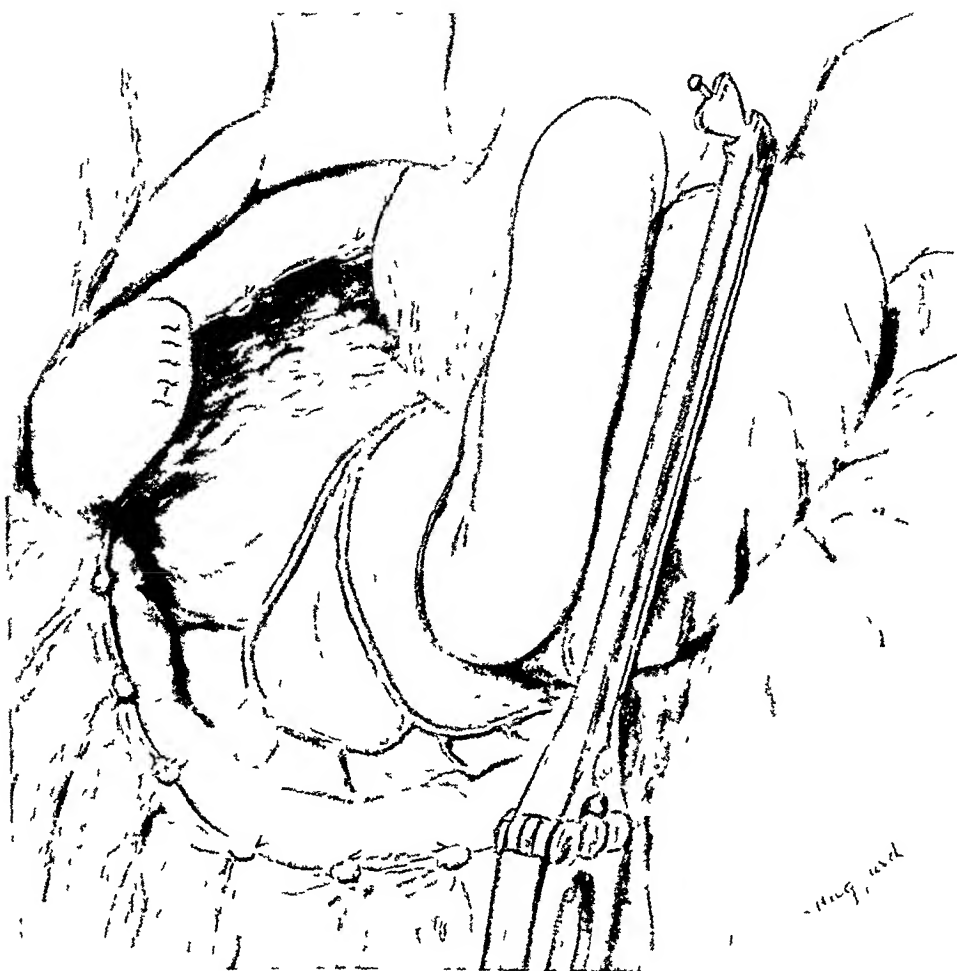


FIG 9—The jejunal loop brought up to the stomach through an opening in the mesentery of the colon

ing the nut is sufficient to maintain a firm grasp on the stomach wall and thus obviates escape of gastric contents

Relative Position of the Jejunum and Colon—In spite of the fact that many surgeons⁸ now favor the antecolic position of the jejunum, we have continued to bring it through a rent in the mesocolon placed as far as possible from the colonic margin, and so far have had little reason to discredit this method. In the last 50 patients, we have had trouble only once with obstruction to the gastric outlet. At reoperation, a phlegmonous condition of the anastomotic site was found, but we were unable to detect whether it was due to catgut allergy or mild infection. It is true that in this particular

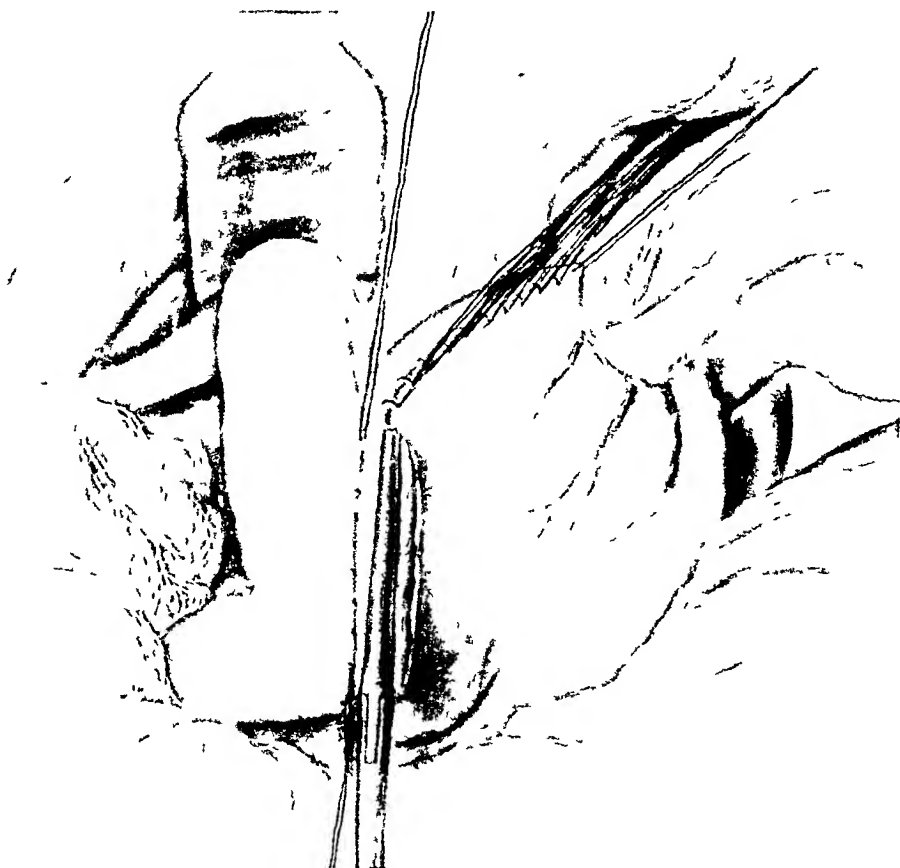


FIG. 10.—The portion of the stomach on the lesser curvature side has been closed. The proximal jejunum has been brought to the lesser curvature and the distal jejunum to the greater curvature.

instance some of the difficulty might have been obviated if an antecolic position of the jejunum had been used, for the mesocolon was very definitely involved in the mass. We leave only just enough jejunum proximal to the anastomosis to guard against kinking when the stomach is allowed to fall back into position, for it appears to us that the closer to the duodenum the anastomosis is effected, the more nearly will be the approach to the normal physiologic relationship of the stomach and small intestine. An isoperistaltic relationship of the stomach and jejunum is maintained by placing the proximal jejunum in apposition with the lesser curvature of the stomach, because the duodenal contents are more likely to be deflected past the gastric stoma than if an antiperistaltic union is made (Fig. 9).

Anastomosis of Stomach to Jejunum—We now prefer the Hofmeister-Finsterer⁹ type of anastomosis, because the valve formed by the closed end of the stomach above the anastomotic stoma deflects the duodenal contents along the jejunum rather than into the stomach as occurs with the Reichel-Polya¹⁰ technic. This observation has been verified on many occasions by finding that the bile appears in the gastric tube 24 hours later and is definitely less in amount after the Hofmeister-Finsterer anastomosis. Further-

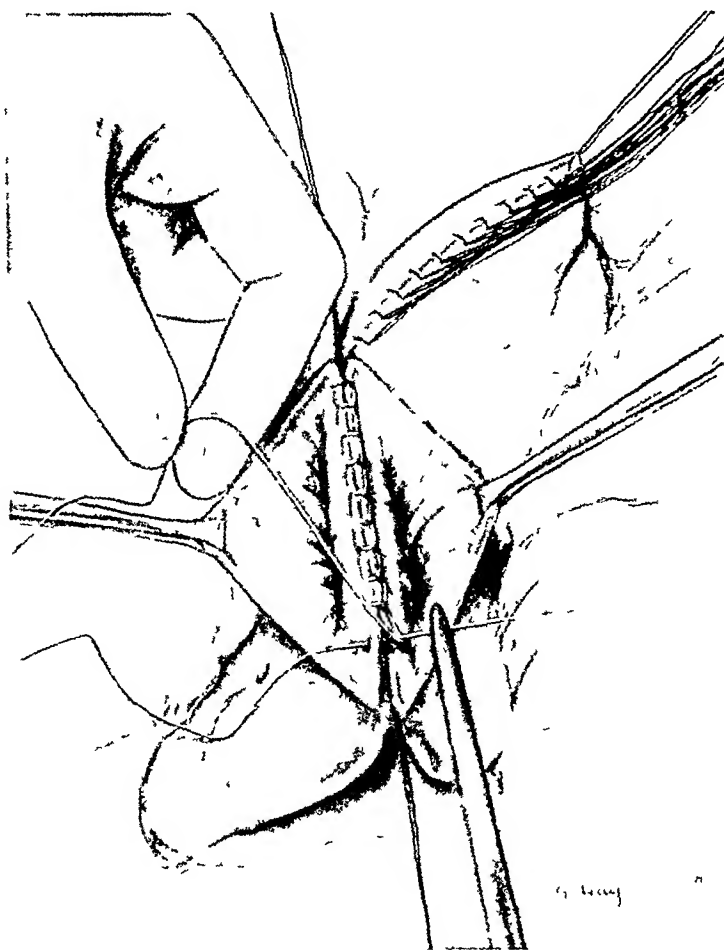


FIG. 11.—The suturing of the posterior wall of the stomach to the jejunum

more, since abandoning the Reichel-Polya operation, our patients have not complained of occasional vomiting of bile, a complication that not infrequently occurred with this technic.

In closing the cut end of the stomach above the proposed anastomotic site (Fig. 10), we have found it convenient to commence the interlocking catgut suture at the upper limit of the stoma rather than at the lesser curvature. This provides a fixed point to work from and facilitates the infolding of the upper angle because of the downward traction that can be exerted by the catgut. The suture is then carried back to its starting point, using the continuous Lembert stitch. A second row of interrupted Lembert sutures of fine silk on milliner's needles is then put in, beginning at the lesser curvature and continued down to the proposed anastomotic site. The last two Lembert

sutures of fine silk are not tied, but the ends are grasped with an artery clamp, and they are laid aside until the anastomosis is completed. Tying these two sutures after the anastomosis is made, more effectively closes the so-called dangerous angle. This area receives additional support when the jejunum proximal to the stoma is united to the previously closed end of the stomach.

In fashioning the anastomosis, two points are worthy of attention. The first is to guard against rotation or kinking of the jejunum by using guide



FIG. 12.—The completed anastomosis showing the reinforcement of the closed portion of stomach by jejunum.

sutures to fix the two ends of the line of suture uniting the stomach to the jejunum (Fig. 11), and the second is to insert the posterior continuous suture between the viscera well toward the mesenteric border of the jejunum so that sufficient jejunal wall remains for the anterior row of interrupted silk sutures after the encircling continuous catgut suture is put in. It is also important when reinforcing the lower angle of the anastomosis to take only small bites with the suture on the jejunal side lest narrowing of the jejunum below the stoma should occur (Fig. 12).

Closing of the Aperture in the Mesocolon—The opening of the mesocolon is placed as close to the spine as possible and to the left of the main trunk of the middle colic artery to guard against involvement of the colon, should an anastomotic ulcer develop, and to prevent injury to the artery when the open-

PARTIAL GASTRECTOMY

ing is closed We endeavor to pull the completed anastomosis down through the aperture in the mesocolon so as to suture the margins to the stomach and place the anastomosis in the infracolic compartment (Fig 13) The procedure is impossible in certain high resections and when there is a foreshortening of the mesocolon Then it is necessary to suture the margins of the aperture in the mesocolon to both the afferent and efferent loops of jejunum and

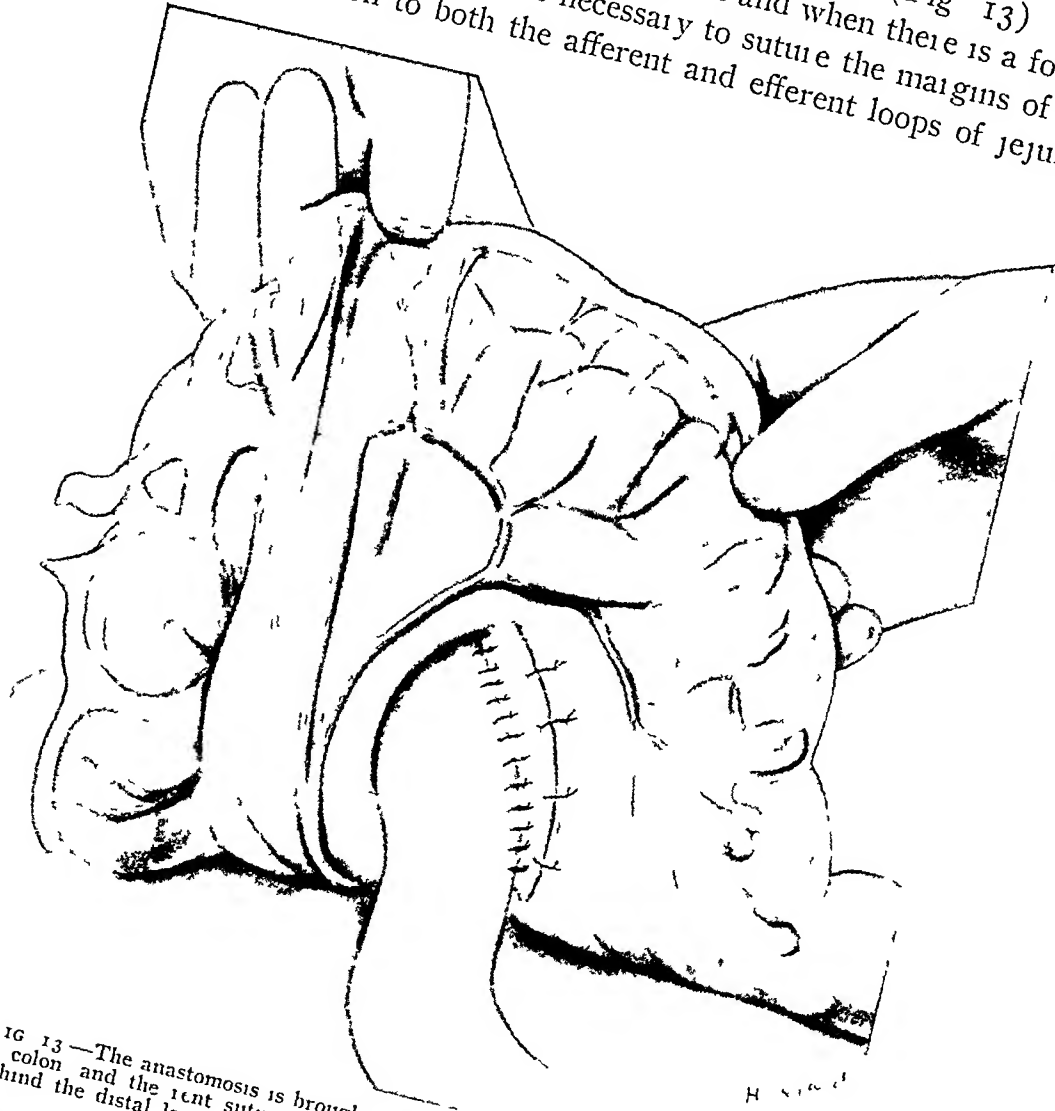


FIG 13 —The anastomosis is brought down through the opening in the mesentery of the colon and the rent sutured to the stomach The proximal loop of jejunum lies behind the distal loop

also to close the opening between the loops with a purse-string suture of fine silk which should include the edge of the mesocolic opening

Drainage —In the usual case, drainage is not necessary, but if a duodenal or gastric ulcer has been left *in situ*, or the pancreas has been injured, or there is any question of the security of the duodenal closure, it is good practice to bring a cigarette drain out through a stab wound at the outer border of the right rectus muscle All collection of fluid in this area tends to pool in the space between the right kidney and the liver, so the drain should be placed down to this site If the duodenum leaks and there is no drainage tube, fatal peritonitis is likely to follow, but if the duodenal contents drain externally, the patient's life may be saved

Postoperative Care—Continuous gastric suction has solved many of the problems of postoperative care, and we consider that its use constitutes the greatest single advance in surgery of the stomach. We leave the tube in the stomach through the fourth postoperative day, and on the fifth day the tube is clamped off at four-hourly intervals. When the four-hourly residue is less than 100 cc, the tube is removed. During the period the tube is in place, the patient is allowed chipped ice and small amounts of water at frequent intervals, all of which tend to allay thirst and contribute much to the patient's comfort. After removal of the tube, water is given in increasing amounts, and when it is well tolerated, milk and water, half-and-half, are substituted. If all goes well, cream and milk are given at regular intervals, and gradually the diet is increased until the patient is able to take a bland diet. Alkaline powder or amphogel is administered regularly to control any tendency to hyperacidity. It is well to proceed with caution, and if there is any evidence of food intolerance, liquid diet should be restored and then gradually increased. In general, the chief source of difficulty is the tendency to increase the diet too rapidly.

SUMMARY—A description with illustrations of the authors' method of handling some of the important steps in partial gastrectomy is presented. No attempt is made to consider the operation in full. The discussion is based on the authors' personal experience with the problems.

CONCLUSIONS

The operation of partial gastrectomy is a procedure of some magnitude. Success is due to many factors, chief of which is the personal experience of both the assistant and the surgeon and for which there is no substitute. Secondary factors are the proper anesthetic, prevention of shock during operation, and adequate postoperative care. It is not an operation that should be undertaken by the occasional operator.

REFERENCES

- ¹ Hartman, F. W., and Schelling, V. Studies of Hexyl-chloro-m-cresol and Other Carbo-cyclic Antiseptics. *Amer Jour Surg*, 46, 460-467, 1939.
- ² Jones, W. H. Spinal Analgesia, a New Method and a New Drug—Percaine. *Brit Jour Anaesth*, 7, 99-113, April, 1930.
- ³ McClure, R. D., Hartman, F. W., Schnedorf, J. G., and Schelling, V. Anoxia—A Source of Possible Complications in Surgical Anesthesia. *ANNALS OF SURGERY*, 110, 835-850, 1939.
- ⁴ Miller, G. Subtotal Gastric Resection for Peptic Ulcer. *Surg, Gynec and Obstet*, 65, 489-494, 1937.
- ⁵ McClure, R. D. A Clamp for Closure of the Duodenal Stump in Gastric Resections, a Modification of the Furniss Clamp. *ANNALS OF SURGERY*, 109, 1034-1035, 1939.
- ⁶ Ogilvie, W. H. Approach to Gastric Surgery. *Lancet*, 2, 235-239, July 30, 1938.
- ⁷ Konjetzny, G. E. Chronische Gastritis und Magenkrebs. *Monatschr f Krebsbekampf*, 2, 65-78, March, 1934.
- ⁸ Marshall, S. F., and Kiefer, E. D. Partial Gastrectomy for Gastric or Duodenal Ulcer. *JAMA*, 109, 1341-1347, October 23, 1937.
- ⁹ Lahev, F. H., and Marshall, S. F. Surgical Treatment of Peptic Ulcer Based upon

130 Subtotal Gastrectomies for Peptic Ulcer New England Jour Med, 217, 933-940, December 9, 1937

¹⁰ Finney, J M T, and Hanrahan, E M, Jr In Lewis, Practice of Surgery Hagerstown, Md, W F Prior and Co, Inc, 6, Chap 8, 1929

DISCUSSION—DR SAMUEL F MARSHALL (Boston, Mass) I consider it a pleasure and privilege to have the opportunity of discussing Doctor McClure's paper, because I was with him for so many years before I went to Boston

In the Lahey Clinic the management of patients with gastric or duodenal ulcer is controlled by the Department of Gastro-Enterology Consultation with members of the Surgical Staff is obtained for those patients who have failed to obtain relief of their ulcer distress by conservative medical measures, or for those patients in whom some serious complication of chronic ulcer has developed, such as repeated massive hemorrhage, obstruction, *etc* By this method, surgical management has been necessary in only 82 per cent of cases of duodenal ulcers, and in 23 per cent of cases in which a diagnosis of gastric ulcer was established

Doctor Lahey has always advocated conservatism in the surgical management of patients with ulcer and, because of the magnitude of the operation, has been slow in accepting subtotal resection of the stomach as the method of choice for these patients until it was proven that the best results were obtained by this operation This is indicated by the gradual increase in the number of subtotal gastrectomies during the past ten years Ten years ago, of those patients with ulcer who were submitted to operation, 70 per cent had a conservative operation, and 30 per cent had a resection To-day, 70 per cent have resection, whereas only 30 per cent have conservative operative procedures, an exact reversal We prefer subtotal resection of the stomach for either duodenal or gastric ulcer, but we do not hesitate to employ gastro-enterostomy in a few selected cases, chiefly in those patients who are bad risks for an extensive operation, or in those patients who are past middle age, who have a low gastric acidity and who have a high grade of cicatricial obstruction

While it may be conceded that the best results from surgical management of ulcer follow high resection of the stomach, the real criterion for its employment is, can this operation be performed with a reasonable margin of safety? Doctor McClure has demonstrated that, with meticulous attention to the details of the operation, the mortality can be kept at a very low level His report of one death in 53 subtotal resections for ulcer is indicative of this

Our results following this operation have been somewhat similar to those of Doctor McClure The most important single factor in reduction of the mortality is experience with this type of gastric surgery, and in most instances this experience has been painfully acquired A number of years ago, in the Lahey Clinic, our mortality with this operation was 18 per cent—a prohibitive mortality, then it was 11 per cent, and, finally, in our last series of cases, one death occurred in 88 consecutive resections for ulcer We have included resection for gastrojejunal ulcer in this group

In addition, then, to the very important factor of experience, meticulous attention to the technical details of the operation makes it possible to perform this procedure with a low mortality Doctor McClure has emphasized the painstaking care necessary throughout the operation, and we can state, from our own experience, that this is absolutely necessary if a high mortality is to be avoided

Our technical procedure differs somewhat from the procedure which Doctor McClure employs, but, in the main, these differences are not of great

Postoperative Care—Continuous gastric suction has solved many of the problems of postoperative care, and we consider that its use constitutes the greatest single advance in surgery of the stomach. We leave the tube in the stomach through the fourth postoperative day, and on the fifth day the tube is clamped off at four-hourly intervals. When the four-hourly residue is less than 100 cc, the tube is removed. During the period the tube is in place, the patient is allowed chipped ice and small amounts of water at frequent intervals, all of which tend to allay thirst and contribute much to the patient's comfort. After removal of the tube, water is given in increasing amounts, and when it is well tolerated, milk and water, half-and-half, are substituted. If all goes well, cream and milk are given at regular intervals, and gradually the diet is increased until the patient is able to take a bland diet. Alkaline powder or amphogel is administered regularly to control any tendency to hyperacidity. It is well to proceed with caution, and if there is any evidence of food intolerance, liquid diet should be restored and then gradually increased. In general, the chief source of difficulty is the tendency to increase the diet too rapidly.

SUMMARY—A description with illustrations of the authors' method of handling some of the important steps in partial gastrectomy is presented. No attempt is made to consider the operation in full. The discussion is based on the authors' personal experience with the problems.

CONCLUSIONS

The operation of partial gastrectomy is a procedure of some magnitude. Success is due to many factors, chief of which is the personal experience of both the assistant and the surgeon and for which there is no substitute. Secondary factors are the proper anesthetic, prevention of shock during operation, and adequate postoperative care. It is not an operation that should be undertaken by the occasional operator.

REFERENCES

- ¹ Hartman, F. W., and Schelling, V. Studies of Hexyl-chloro-m-cresol and Other Carbo-cyclic Antiseptics. *Amer Jour Surg*, **46**, 460-467, 1939.
- Jones, W. H. Spinal Analgesia, a New Method and a New Drug—Percame. *Brit Jour Anaesth*, **7**, 99-113, April, 1930.
- ³ McClure, R. D., Hartman, F. W., Schnedorf, J. G., and Schelling, V. Anoxia—A Source of Possible Complications in Surgical Anesthesia. *ANNALS OF SURGERY*, **110**, 835-850, 1939.
- ⁴ Miller, G. Subtotal Gastric Resection for Peptic Ulcer. *Surg, Gynec and Obstet*, **65**, 489-494, 1937.
- ⁵ McClure, R. D. A Clamp for Closure of the Duodenal Stump in Gastric Resections, a Modification of the Furniss Clamp. *ANNALS OF SURGERY*, **109**, 1034-1035, 1939.
- ⁶ Ogilvie, W. H. Approach to Gastric Surgery. *Lancet*, **2**, 235-239, July 30, 1938.
- ⁷ Konjetzny, G. E. Chronische Gastritis und Magenkrebs. *Monatschr f Krebsbekampf*, **2**, 65-78, March, 1934.
- ⁸ Marshall, S. F., and Kiefer, E. D. Partial Gastrectomy for Gastric or Duodenal Ulcer. *J A M A*, **109**, 1341-1347, October 23, 1937.
- ⁹ Lahey, F. H., and Marshall, S. F. Surgical Treatment of Peptic Ulcer Based upon

130 Subtotal Gastrectomies for Peptic Ulcer New England Jour Med, 217, 933-940, December 9, 1937

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Our technical procedure differs somewhat from the procedure which Doctor McClure employs, but, in the main, these differences are not of great

importance We employ, almost routinely, a modified Hofmeister method of gastrojejunostomy It is well to emphasize that if resection is decided upon, it should be radical, at least three-fourths to four-fifths of the stomach should be removed in all instances The best results follow such an extensive resection, and recurrence of the ulcer is less apt to result after high resection

We have not prepared our patients before operation with the type of antiseptic that Doctor McClure mentions, and we have had no experience with such an antiseptic We know that the stomach will sterilize itself rapidly in the presence of normal gastric acidity, and this is particularly true in the presence of high acidity which so commonly accompanies ulcer Cushing demonstrated this fact years ago Consequently, we stop all alkaline therapy several days before operation, and as a result can practically eliminate the incidence of infection following operation

We have employed the dePetz clamp in practically all of our resections It enables us to reduce the time of the operative procedure, prevents spilling of gastric contents, and controls hemorrhage from the divided end of the stomach

Another point of interest is whether the antecolic or a transmesocolic anastomosis should be employed After considerable experience, we have adopted the use of the antecolic gastrojejunostomy This method reduces the operative time and, in our experience, postoperative obstruction practically never occurs

It must be remembered that ulcers will recur, even with high resections of the stomach, though fortunately infrequently Should such an ulcer follow a high resection, it is immeasurably easier to resect if an antecolic anastomosis has been made than if posterior anastomosis has been employed We, too, routinely employ spinal anesthesia, using nupercain in 1:1,500 dilution, and believe this anesthesia is a considerable factor in increasing the margin of safety

I think Doctor McClure is to be congratulated upon his excellent results following subtotal resection of the stomach for ulcer

CHRONIC OBSTRUCTION OF THE PROXIMAL DUODENUM BY CONGENITAL BANDS*

GEORGE H BUNCH, M D , AND ROGER G DOUGHTY, M D

COLUMBIA, S C

IN 1936, McGehee and Anderson¹⁰ read a paper before this association on "Chronic Obstruction of the Duodenum of Congenital Origin," which they say is a definite pathologic and clinical entity amenable to surgical treatment. As do most writers, they limit discussion to obstruction of the terminal duodenum resulting from imperfect rotation of the intestine so that the duodenum is twisted upon itself or is compressed by the superior mesenteric blood vessels, which causes chronic dilatation of the proximal duodenum demonstrable both roentgenologically and at operation. Madigan¹⁷ reports a case in which the distended second portion of the duodenum filled the pelvis, and in Higgins'¹⁵ 56 cases of duodenal obstruction from all causes the duodenum was found distended in every case.

In contrast to this, we shall briefly report three cases of chronic obstruction of the proximal duodenum from developmental bands derived from the anterior mesogastrium. In none was the duodenum found dilated.

Bland-Sutton has called the duodenum the region of embryonic events. The first portion is derived from the foregut and is comparatively free from extrinsic developmental anomalies. The second and third portions, however, come from the midgut which is, embryologically, the most active portion of the intestine and affords increased opportunity for developmental error. Harris² has called attention to the obstructing effect of congenital bands which, crossing the second portion of the duodenum from below, pass upward to the right and terminate in the region of the gallbladder. They are the anomalous remains of the anterior mesogastrium which has failed to follow its development to the normal conclusion. Although found by anatomists long ago, the mechanical effect of these bands on the duodenum has only recently been appreciated by surgeons. Occurring as broad bands of fibrous adhesions lying obliquely across the duodenum, these "cobwebs in the attic" of the infant, although of embryonic origin, are not unlike the adhesions in this region in adult life resulting from chronic inflammation.

In the infant, obstruction of the duodenum may be intrinsic or extrinsic in origin. Complete obstruction is most frequently caused by atresia of the intestine, incomplete, by congenital pyloric stenosis. Both are intrinsic in type in distinction from obstruction by congenital bands which is extrinsic.

Preoperative differentiation in cases of complete obstruction is most often impossible but in incomplete obstruction it can usually be made. Congenital pyloric stenosis, as a rule, occurs in the first male child and symptoms

* Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

begin in the second or third week after birth. The obstruction being above the ampulla of Vater, bile does not enter the stomach and is not found in the vomitus. Donovan¹² says the pathognomonic olive-shaped tumor mass of hypertrophied muscle may be felt in every case of congenital pyloric stenosis if the examination is made with the stomach empty and the child relaxed. In sharp contrast to this, when the proximal duodenum is obstructed by congenital bands, vomiting starts soon after feedings begin. The vomitus in our three cases contained bile. Pattern-waves, from peristaltic contraction of the stomach wall and projectile vomiting of ingested food, were present in both infants operated upon by us. In none of our cases was the duodenum dilated, for in all, both the first and most of the second portions were hyperfixed and constricted. Dilatation from obstruction develops only in segments of the intestine proximal to an obstruction.

The predominant symptoms are nausea and vomiting, usually beginning with the first feedings of the newborn. If the obstruction is incomplete, there are periods of exacerbation and remission. Persistent gastric stasis in the infant, as in the adult, suggests obstruction, the degree of which may be learned from clinical observation and from roentgenologic study. As the child becomes older, in spite of every care, the clinical picture is that of chronic starvation of varying severity depending upon the degree of obstruction. Sickly and undernourished, the patient instinctively avoids bulky foods. Insufficient food residue causes small, infrequent, scybalous movements rather than true constipation. Older children, after eating, complain of gaseous distention and epigastric distress which is relieved by vomiting.

The prognosis depends upon the degree of obstruction and upon the management of the individual case. When the obstruction is complete, operation is imperative. High intestinal obstruction, from all types of congenital lesions, probably occurs about once in every 20,000 births. Nevertheless, Miller,⁹ in 1939, found in the literature only five cases of complete obstruction of the duodenum in the newborn, due to abnormal bands, which recovered. Although, as was shown in the discussion of his paper, he underestimates the true number of successful cases, when the probable incidence is kept in mind the pitifully small number of successes eloquently speaks the need for recognition of the condition. When the obstruction is incomplete, chronic starvation of varying degree may continue even into adult life. Kantor^{4, 5} presents correlated roentgenologic and operative findings to support his estimate that 4 to 5 per cent of the cases of epigastric discomfort in adults are due to congenital bands or other anomalies. It is an interesting fact, however, as pointed out by Nook, that most people with anomalies of rotation go through life without ever becoming aware of them.

Symptoms of incomplete obstruction not relieved by medical treatment, continued for a reasonable time, demand surgical exploration. Before operation glucose and normal salt solution should be administered to overcome dehydration and to prevent acidosis. At operation, with the stomach pulled to the left and the liver retracted upward and to the right, the constricting

bands may be demonstrated. They should be cut along the avascular, outer margin of the duodenum as it is mobilized by being gently pulled mesially and to the left. In young infants feeding should be begun early, as after the Rammstedt operation for congenital pyloric stenosis. When free, congenital bands do not seem to reform, and recurrence of the obstruction has not been reported.

CASE REPORTS

Case 1—Twenty-four hours after a normal delivery, a female infant began vomiting. At the end of 48 hours, the vomiting became projectile in type and contained food particles stained a deep yellow. When seen on the third day, the upper abdomen was distended and the stomach visibly outlined. Typical peristaltic waves passed from left to right, but no mass could be palpated. The obstruction was thought to be below the level of the ampulla because the vomitus contained bile.

At operation, the gallbladder, duodenum and transverse colon were adhered and the stomach distended due to duodenal obstruction. The adhesions were freed and the first portion of the duodenum released from bands which flattened and obstructed it. There were additional adhesions along the second portion which were also released. The postoperative course was uneventful and to date, four years later, the patient has remained well.

Case 2—R. M. S., a bottle fed boy, age six months, the mother's first child, was admitted to the Columbia Hospital, for the relief of vomiting and progressive loss of weight. He had always been constipated and had vomited often. After being treated by a pediatrician at the age of three months, he improved but after five months continuously lost weight from vomiting. Fluoroscopic examination showed barium passing very slowly through the duodenum, instead of rapidly as in the normal infant. There was almost 50 per cent retention in the stomach after five hours.

At operation, the first and second portions of the duodenum were found flattened and partially obstructed by fibrous bands passing across them from the transverse colon to the under surface of the liver. These were freed. Postoperatively, the patient has had complete relief from digestive symptoms and is well to-day, three years after operation.

Case 3—J. S., a boy, age 11, entered the Columbia Hospital, complaining of persistent vomiting. He was an only child. His mother gave the significant history that he had vomited every day of his life. As an infant he nursed greedily and after a few minutes vomited. He had repeated attacks of rickets and of acidosis. As a child his appetite was poor and solid food made him ill.

Physical examination on admission was negative, except for pallor, weakness and emaciation. The abdomen was flat and without tenderness or masses. The hemoglobin was 60 per cent. Fluoroscopic study of the stomach after ingestion of barium showed marked retention with incomplete obstruction at or near the pylorus.

Surgical exploration, under ether anesthesia, was performed through a right rectus incision. The first and second portions of the duodenum were partially obstructed by transverse fibrous bands which extended to the under surface of the right lobe of the liver. The duodenum was constricted and flattened, being pulled upward, and somewhat angulated. The pylorus was normal. As the bands were separated and the duodenum mobilized, the intestine assumed its normal position and contour. Following operation there never was any nausea. The patient enjoyed his meals for the first time in his life, and has been normal in every way during the eight years since operation.

In summary, we wish to call attention to the fact that Case 1 had at birth complete chronic obstruction of the proximal duodenum by congenital bands. Early operation, we feel, undoubtedly saved the baby's life. Cases 2 and 3

had incomplete obstruction, and were six months and 11 years old, respectively, at the time of operation. They had both reached a severe degree of chronic starvation before being subjected to exploration, in spite of the fact that in both, symptoms suggestive of obstruction had been continuously present since birth. Both had been repeatedly under the care of well-known clinicians who had vainly sought relief by dietary methods.

While we are admittedly dealing with a rare condition, we are convinced that the rôle played by congenital anomalies of the intestine in chronic digestive disorders is not appreciated. We believe there have been many lives lost in infants because of the failure to recognize the mechanical obstruction as the cause of vomiting and because of unwise and unwarranted persistence in dietary regimen. In our opinion, many young adults are, also, similarly mistreated.

We urge the judicious employment of the barium meal for the recognition of high obstruction. However, when involvement is lower in the intestinal tract the danger of precipitating an acute obstruction by the ingestion of barium must be considered. The necessity for surgical exploration in cases with obstructive symptoms that do not respond to medical treatment we think is so obvious that it is mandatory.

REFERENCES

- ¹ Buchanan, E. P. Congenital Duodenal Obstruction from Anomalous Mesenteric Vessels. *Am Jour Surg*, 30, 499-501, December, 1935.
- ² Harris, M. L. Constrictions of the Duodenum Due to Abnormal Folds of the Anterior Mesogastrium. *J A M A*, 62, 1211, April 18, 1914.
- ³ Jackson, R. H. Congenital Constriction of the Duodenum Due to an Abnormal Fold of the Anterior Mesogastrium. *ANNALS OF SURGERY*, 84, 723-728, 1926.
- ⁴ Kantor, J. L. Practical Significance of Digestive Tract Anomalies. *Jour Michigan Med Soc*, 30, 820-828, November, 1931.
- ⁵ Kantor, J. L. Common Anomalies of Duodenum and Colon, Their Practical Significance, Result of Eight Years' Combined Clinical and Roentgen Study. *J A M A*, 97, 1785, December 12, 1931.
- ⁶ Kelly, J. F. Partial Intestinal Obstruction Due to Congenital Anomaly of Duodenum, and Partial Rotation of Colon. *Am Jour Surg*, 22, 299-302, November, 1922.
- ⁷ Kellogg, E. L. Abnormalities in the Shape and Position of the Duodenum. *Am Jour Surg*, 12, 462-465, June, 1931.
- ⁸ Kellogg, E. L., and Collins, J. T. Congenital Duodenal Obstruction. *Am Jour Surg*, 30, 369-371, November, 1935.
- ⁹ Miller, E. M. Bowel Obstruction in the Newborn. *ANNALS OF SURGERY*, 110, 587-605, October, 1939.
- ¹⁰ McGehee and Anderson. Chronic Obstruction and Dilatation of the Duodenum. *Trans South Surg Assn*, 49, 111, 1936.
- ¹¹ Morton and Jones. Obstruction about the Mesentery in Infants. *ANNALS OF SURGERY*, 104, 864, November, 1936.
- ¹² Donovan, E. J. Congenital Hypertrophic Pyloric Stenosis. *Am Jour Surg*, N S, 39, 377, February, 1938.
- ¹³ Jones and Morton. Congenital Malformation of the Intestine in Children. *Am Jour Surg*, N S, 39, 382, February, 1938.
- ¹⁴ Ladd, W. E. Congenital Duodenal Obstruction. *Surgery*, 1, 878, June, 1937.
- ¹⁵ Higgins, C. C. Chronic Duodenal Ileus. *Arch Surg*, 13, 1, July, 1926.

- ¹⁶ Marx, R Nonrotation of the Intestine ANNALS OF SURGERY, 109, 49, January, 1939
¹⁷ Madigan, J P A Case of Megalostria and Megaduodenum South Med Jour, 24, 939, 1934 Quoted by Jones, Int Abs Surg (in Surg, Gynec and Obstet), 63, 420, November, 1936

DISCUSSION—DR L W GROVE (Atlanta, Ga) I would like to present two cases to emphasize two points First, as suggested by Doctor Doughty and recently by Doctor Ladd, that anomalies of the gastro-intestinal tract are much more frequent than we realize, and that while definite anomalies may exist they often present no symptoms until complicated by some acute abdominal pathology, and, second, to call attention to a very unusual complication arising in a case of acute lymphatic leukemia

CASE REPORTS

Case 1—The first case came to us in 1933, a young woman, age 19, in perfect health until two months before admission to the hospital, at which time she suffered an acute abdominal catastrophe, diagnosed, and I think correctly, as acute mesenteric adenitis Following this she began to have recurrent attacks simulating a high intestinal obstruction A roentgenologic study confirmed the diagnosis of a partial obstruction high in the jejunum It also showed a nonrotation of the colon These findings were confirmed at operation The cecum had not rotated beyond the midline It was behind the small bowel which was rotated to the left on the superior mesenteric root, with loops of jejunum adherent to nodes in the roots of the mesentery at several points, causing multiple points of partial obstruction The small bowel was freed at these points and rotated into normal position The cecum was then rotated and fixed in its normal position She has had no further trouble

Case 2—The second case was a child, two years old, who came under observation two years ago Apparently, she had been well until two weeks before admission, at which time there was evidence of acute tonsillitis, accompanied by vomiting The tonsillitis quickly subsided but she continued to vomit There were enormous amounts of bile in the vomitus and, apparently, very little food was passing through the stomach At this time, roentgenologic examination was made, which showed definite obstruction with marked six-hour gastric retention At the end of 24 hours, there was almost complete obstruction of the third portion of the duodenum She was operated upon, and there was found almost complete obstruction of the duodenum caused by pressure from the superior mesenteric vessels In this area there were several mesenteric nodes matted together, which caused complete fixation of the mesenteric root A duodenojejunosomy was performed, without clamps Her convalescence was uneventful, without further vomiting, and she was dismissed from the hospital at the end of two weeks Two months later, she was readmitted Examination revealed a generalized adenopathy, a high temperature, purpuric spots and a blood picture diagnostic of an acute lymphatic leukemia Unfortunately, autopsy was not obtained The enlarged mesenteric nodes found at operation were probably the first evidence of the leukemia, which was not recognized at that time

DR K H AYNESWORTH (Waco, Tex) I have, for a long time, been very much interested in the embryologic significance of this region We know that, in the evolution of man, many changes took place which have pathologic significance Some of these changes are similar to the scaffolding of a building, useful in construction, but should be removed when the building is completed There are embryologic adhesive bands in the region of the gallbladder and duodenum which, later, may cause trouble by obstructing the bowel and end in tragedies In a pronograde animal, the mesenteric attachment is simple, and along the dorsal spine When the ancestral man assumed the upright position, there were many supporting structures devised to hold

the intestines and viscera in correct position, some of which were defective and others were of possible pathologic significance

Roughly speaking, the foregut is a region which prepares the food for digestion. The midgut is the region which continues the chemical action upon the food which began in the foregut, and the hindgut expels the remains of both food and secretions poured into the bowel. The rotation of the intestines begins with the embryologic development about the fourth week and ends about the tenth week. Rotation and fixation of the intestines begin at the upper end of the small intestine and rotate to the left. When doing so, there are many adventitious bands which form in this region and the remains of these are the ones which produce obstruction in later life.

DR ROGER DOUGHTY (Columbia, S. C., in closing) I think we have nothing to add, except that we wish to thank the gentlemen for their discussion. If we have drawn attention to the lesion in such a way as will in future assist in early recognition of the condition, I think that we have accomplished our purpose.

NONMALIGNANT OBSTRUCTION OF THE INTESTINE*

MICHAEL JOSEPH HENRY, M D

LOUISVILLE, KY

DURING the past few years the manner of dealing with intestinal obstruction due to carcinoma or other malignant growths has become fairly well standardized. It does not present the wide variety of causative conditions, its onset is less frequently sudden, and its end-results are determined more by the degree of involvement of neighboring or distant structures, than by the extent of the obstruction. In malignant obstruction one rarely has to deal with alterations in the circulation to the bowel above the obstruction, while in those cases due to nonmalignant causes the blood supply to the tissues above the point of blockage is frequently the chief factor in determining the outcome. Nonmalignant and malignant obstruction cannot be well considered in any brief article. For this reason I shall confine my discussion to the results obtained in our series of intestinal obstruction due to nonmalignant conditions. I shall further confine it to those cases subjected to surgical treatment.

The advent of the catheter-like duodenal tube, which can be introduced transnasally, has brought about a marked change in the methods of dealing with the various types of ileus. Since its introduction many cases formerly thought to demand surgical treatment for their alleviation now can be completely relieved, or put into such condition that any operative measures to overcome the effects of stasis can be undertaken with less risk. This is particularly true in those cases of adhesive obstruction resulting from a recent operation.

In the postoperative course of abdominal procedures there often occur instances of distention and vomiting, with or without pain. These frequently tax the judgment of the surgeon when he tries to determine whether or not an obstruction exists, and if existent, whether or not it is complete. Prior to the use of the duodenal tube many of these were subjected to operative interference, which, if they occurred to-day, could be relieved by prolonged tubal drainage of the upper intestinal tract.

A duodenal tube may be easily introduced through the nose, into the stomach, from which it passes into the upper intestinal tract. Very satisfactory decompression of the tract can be effected when suction is applied to this tube. We use the Foss apparatus to produce this suction and have found it very simple and satisfactory.

We have had a very limited experience with the use of the Miller-Abbott tube. The reports of those who have had more experience in its use seem to indicate that in cases of obstruction it will prove a valuable addition in the treatment. Paralytic ileus is, perhaps, the most promising field for its use.

* Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

Any procedure which can reduce the mortality in cases of interruption in the continuity of the bowel lumen will prove welcome to every surgeon. A study of our own cases shows that the mortality under the older methods is high. The high mortality should, when possible, lead one to the now more conservative methods of dealing with these cases.

The use of the conservative measures to treat cases of ileus will call for much more accurate diagnoses, since the problem of some major interference with the circulation in the distended bowel will demand the use of the highest degree of discrimination. While it is true that abdominal tenderness does give some information as to the condition of the intestinal wall, the occurrence of obstruction soon after operations for inflammatory lesions finds an abdomen that has not been free of tenderness since the onset of the primary disease, and thus lessens the value of this finding in cases presenting impaired circulation.

Unless one occasionally looks critically at the record, one is likely to hold erroneous views as to one's own success or failure in any field.

For the purpose of determining our results in the surgical treatment of nonmalignant obstruction, I have reviewed the histories in our own files. Seventy per cent of these cases were operated upon by Dr. Irvin Abell, the remainder by me. Since I have been associated with Doctor Abell for nearly 25 years, more than 90 per cent of the cases have come under my observation.

All the cases considered in this study are of the complete or almost complete type. Ninety-one per cent were of the complete variety. Obstructions of mild or moderate degree and those treated conservatively have not been included.

In this series, pain and vomiting were present in more than 95 per cent of the cases. The frequent occurrence of vomiting is, no doubt, due to the fact that so many of the patients had obstructions to the small intestine, and many came to the hospital long after the onset of obstructive symptoms. Distention was the next most frequently encountered finding, but in our series it was not of sufficient frequency or degree to be of diagnostic importance.

The length of time elapsing between the onset of symptoms and the institution of treatment is shown in Table I.

TABLE I
HISTORIES STATING TIME OF ONSET (124)

	No of Cases
Less than 12 hours	12
From 12 to 24 hours	27
From 24 to 48 hours	24
From 2 to 5 days	35
More than 5 days	26
Total	124

Thus 70 per cent were seen more than 24 hours after the onset of the obstruction

The causes of obstruction in which neoplastic disease is not a factor are shown in Table II

TABLE II
OBSTRUCTION NOT CAUSED BY NEOPLASM

	No of Cases
Adhesions a factor	84
Due to adhesions alone	74
Adhesive bands present	37
External herniae	54
Volvuli	11
Gallstone obturation	7
Intussusception	11
Tuberculosis	4
Mesenteric thrombosis	2
Imperforate anus	1

From Table II it will be seen that adhesions played a part in the production of the symptoms in 46 per cent of the cases, and were the sole cause in 40 per cent. External herniae were responsible for 30 per cent of the obstructions.

In cases of obstruction due to neoplastic disease the large bowel is more frequently the site of the offending lesion, while in the nonmalignant group the reverse is true, as is seen from Table III, which shows the location of the obstruction in this series.

TABLE III
SITE OF OBSTRUCTION IN NONMALIGNANT CASES

	No of Cases
Jejunum	9
Ileum	134
Cecum	2
Ascending colon	1
Transverse colon	7
Descending colon	1
Sigmoid	5
Rectum	1
Total	160

In explanation of the large number of cases occurring in the ileum, it might be stated that in many records the only notation as to localization is that the obstruction was in the small intestine. When the complete record did not indicate the jejunum to be the involved segment, the obstruction has been tabulated as occurring in the ileum. Duodenal obstructions have not been considered in this group of cases because they are so frequently indistinguishable from pyloric obstructions.

The laboratory gives very little aid in the recognition of the presence of obstruction. The more pronounced the obstruction the less importance is to be placed upon laboratory findings. In the incomplete or chronic type of obstruction is found the greatest usefulness of the laboratory, since a study of the chemistry of the blood may help to disclose its presence.

Blood counts and stained smears of the blood yield little information. In extreme dehydration the hemoglobin content may be high, and there may be a high red cell count. The leukocyte count yields no more information than does the study of the red cell and hemoglobin content, for dehydration or the presence of the disease which caused the obstruction interferes with the accurate interpretation of the study of the leukocytes. In our series, blood counts, including differential studies, were made in practically all cases, yet no definite information is gained by a comparative study of the findings obtained.

Roentgenologic examination is of some aid in the diagnosis of obstruction, but in this series it was employed too infrequently to justify the drawing of any conclusions from this source of information.

As 91 per cent of the obstructions in this series were of the Grade 4 variety, the roentgenogram could have done no more than aid in the localization. Many of our cases occurred before we were aware of the possibilities of obtaining information in this manner.

Recently, we have employed roentgenologic examination in cases of suspected obstruction. We prefer to make the exposures in two positions. The roentgenogram taken in the supine position will show the distended bowel, and by the position of the distended loops one can conjecture as to the location of the lesion producing the blockage. That taken in the upright, or even semiupright, posture gives some information not obtained by the other exposure. Obstruction in the lower ileum sometimes shows a distended bowel which is hard to identify on the film taken in the supine position, since the distention is sometimes so great as to give the impression of a distended loop of colon. Since, in colonic obstruction, there is frequently little or no distention of the small intestine, the presence of many stair-step shadows of fluid and gas, which are much better shown in the upright position, indicates that the obstruction is in the small intestine.

The mortality in intestinal obstruction is high under any circumstances, and when one is considering cases of such severity as to demand surgical intervention, the mortality is correspondingly higher.

Adhesions—In our series of cases the most frequent causative factor was the presence of adhesions, either of the sessile type, or that characterized by the formation of bands.

Adhesions were the sole factor in 74 cases, and of these, 44 gave a history of previous abdominal operations. These operations were equally divided between the recent and remote ones. The mortality in the various types is shown in Table IV.

NONMALIGNANT INTESTINAL OBSTRUCTION

TABLE IV

MORTALITY FOLLOWING OBSTRUCTION BY THE VARIOUS TYPES

All adhesion cases	27 per cent
No previous operation	33 per cent
With previous operation	23 per cent
Operation recent	27 per cent
Operation remote	18 per cent

Of the 20 fatal cases in this series, nine required intestinal resection

It is evident that the most favorable type of adhesive obstruction is that coming late after previous operation. This is probably due to the fact that the general practitioner recognizes the danger of obstruction in persons having abdominal scars, and consequently sends the patient to the surgeon with less delay. Also, there is less likelihood of encountering infection in the remote case.

Following the same line of reasoning, the high mortality rate in those cases with no surgical scars on the abdomen is more likely due to the fact that there is a delay in their reaching the surgeon, often having been treated for "acute indigestion," "gas colic," or perhaps gallbladder disease before the true condition is ascertained.

External Herniae—In dealing with external herniae, one would be justified in expecting a relatively low mortality, which is true. Yet, with such an apparent condition the mortality is too high. No doubt, this can be attributed to the fact that the patient has frequently succeeded in reducing a hernia even after much effort—which gives him a false sense of security, causing him to delay calling a physician. To his error is often added that of the physician, who makes prolonged efforts at reduction, with or without an anesthetic. Such efforts cause delay and traumatize a bowel wall that is easily damaged, bringing about an increase in the seriousness of the operative procedures eventually employed.

In this series there were 54 cases of obstruction due to strangulated hernia. Fifty-three of these were operated upon, with ten deaths, giving a mortality of 19 per cent. These herniae were divided as shown in Table V.

TABLE V

DISTRIBUTION OF STRANGULATED HERNIAE

	No of Cases
Right inguinal	22
Left inguinal	8
Right femoral	11
Left femoral	5
Umbilical	2
Incisional	6
Total	54

Of the ten cases terminating fatally in this group, four required resections of the bowel, which indicates the seriousness of the lesion. One case of sim-

ple release of the incarcerated intestine, with a repair of hernia, died of a pulmonary embolus on the eleventh postoperative day

From the rather high mortality, which is usually the mortality of delay, one sees the necessity of cautioning all those who have herniae that with the development of severe pain in a previously quiet hernia surgical relief should be sought without delay. Especially should this be impressed on the medical profession

Internal Herniae—Three of the cases listed under those due to adhesions were in reality herniations into surgically formed pockets within the abdomen. Two followed operations to suspend the uterus. Both were performed by the method of Gilliam. One followed an operation for prolapse of the cervix with cystocele and rectocele. The body of the uterus had been removed years previously. In correcting this prolapse, bands of the rectus fascia had been brought through the peritoneum and sutured to the cervical stump, thus dividing the entrance to the pelvis into three openings through which loops of intestine could herniate.

Volvulus—Eleven cases of volvulus were seen. One was found at necropsy in a patient dying soon after admittance to the hospital. Of the 10 cases operated upon, five died, a mortality of 50 per cent. The five patients who lived following operation required no more than a simple release of the volvulus. The fatal cases were subjected to the following types of operation (Table VI)

TABLE VI
OPERATIVE PROCEDURES IN THE FATAL CASES

Enterostomy	1
Release plus enterostomy	1
Closed resection, Rankin clamp	1
Resection plus enterostomy	1
Not stated	1
	<hr/>
Total	5

Gallstone Obturation—Obturation obstruction is rarely diagnosed preoperatively. There were seven cases due to this cause. One was found at necropsy, in a patient who entered the hospital in a moribund condition. Six were found at operation. Of these, three died, a mortality of 50 per cent.

There is no class of cases that should offer a better field in which to use tubal drainage of the upper intestinal tract. Since the pathologic process is one of simple blockage, were one able to get the tube beyond the fistula between the gallbladder and intestinal tract, simple decompression should soon render operative removal of the obstructing object a comparatively safe undertaking.

Intussusception—Of this type of obstruction there were 12 cases. One was found at necropsy as being due to invagination of a Meckel's diverticulum which had produced the intussusception in the same manner as does a polyp

There were 11 operative cases, four of which resulted fatally, a mortality of 36 per cent (Table VII)

TABLE VII
TYPES OF INTUSSUSCEPTION

Types of Intussusception	No of Cases
Enteric	2
Ileocolic	4
Ileocecal	3
Colic	3
Total	12
Age Incidence	
Less than nine months	6
Twenty-one months	1
Four to ten years	4
Eighteen years	1
Total	12

In the diagnosis of intussusception the presence of blood in the stool is of great importance. In this series there were only eight cases whose records definitely stated whether or not blood was present. Seven showed that blood had been passed per rectum, while one referred to its absence.

Tuberculosis—There were three cases of obstruction due to adhesions resulting from tuberculous peritonitis, and one due to a tuberculoma of the cecum.

The operative procedures carried out in the four instances were: Release of the obstruction, 2; ileocolostomy, 1; cecocolostomy, 1.

There was one death. It occurred in a patient for whom a simple release of the obstruction had been performed.

Mesenteric Thrombosis—There was one case of thrombosis in the jejunum. This patient survived a resection of the jejunum with a lateral anastomosis. One case of thrombosis of the ileum died, following a resection performed by the Rankin clamp method.

Imperforate Anus—The only case of this type of obstruction occurring in our series was in a premature baby, weighing three pounds. It was operated upon 31½ hours after birth. There were no skin markings to denote the location of the sphincter. The bowel was found 2 cm. above the levatores, and its mucosa was sutured to the skin. The child was in good condition when it left the hospital with its mother on the eleventh day postpartum.

From a study of our records it is evident that the type of operation required determines the percentage of mortality. This may be seen from the statistics in Table VIII.

Resections were required in 30 cases, and resulted in the death of 17 patients, a mortality of 57 per cent.

These resections were performed in the following types of obstruction

TABLE VIII

TYPES OF OBSTRUCTION IN WHICH RESECTIONS RESULTED FATALLY

Adhesions	6
Adhesive bands	3
Intussusception	2
Inginal herniae	2
Femoral herniae	2
Thrombosis	1
Volvulus	1

Enterostomy alone was performed in three instances. All died. A necropsy on one of these patients showed the presence of a volvulus.

Twenty-eight cases were treated by releasing adhesions and performing an enterostomy above the site of obstruction. Of these, 11 died, a mortality of 39 per cent.

Those cases requiring no more than a release of the adhesions producing obstruction were, as would be expected, the most favorable group. In this class there were 48 cases. Eight of them died, a mortality of 17 per cent.

A review such as this, which shows the high mortality present in the radical treatment of obstruction, must result in a correlation of these data with the results obtained under the present methods of dealing with this serious lesion.

Tubal decompression of the intestinal tract should lessen the indications for the operative treatment of obstruction and bring patients to the operating room in much better condition to withstand the hazard of an operation for intestinal ileus.

DISCUSSION—DR JAMES D. RIVES (New Orleans, La.) I would like to say a few words about the pros and cons of the treatment of intestinal obstruction by means of the various types of indwelling catheters. Before doing so, I wish to make it clear that I believe that the mortality of intestinal obstruction depends more upon the time elapsed between its onset, and its relief, than on any other factor, and that any treatment which does not take this fact into consideration will fail.

When the Wangenstein method of continuous aspiration of the intestine was introduced a few years ago, it was adopted in the Charity Hospital at New Orleans with a certain degree of overenthusiasm, by the relatively inexperienced members of the staff. In a period of three years, nine patients whose intestinal tracts had been adequately decompressed by this method died as a result of perforation at the point of obstruction with resulting peritonitis.

In contrast, I would like to report the cases collected at Toulo Infirmary by Doctors Kaplan and Michel. There were 17 cases of various types of ileus in which an attempt was made to relieve the obstruction by means of the Miller-Abbott tube. These cases were supervised by a relatively more experienced personnel, with roentgenologic observation of the introduction of the tube, special nursing care, and the practically constant attention of residents and interns. In the 17 cases in which introduction of the tube was attempted, it was successfully passed beyond the pyloric sphincter in 14. Two

of the failures were in young children. Bowel function was restored and free bowel movements occurred in all 14 cases where successful introduction was accomplished.

There were four deaths in the series. One had been obstructed for four days at the time of admission. Introduction of the tube was not accomplished, and operation failed to save the patient. In three, death resulted from various complications after release of the obstruction. There were no deaths that we feel were attributable to the use of the tube, although there were two rather narrow escapes. In one, the ultimately necessary operation was deferred for 48 hours. Another died with pneumonia, and it was found at autopsy that overinflation of the balloon of the tube had produced excessive distention of the bowel and that necrosis had begun. Had she not died of pneumonia, she would probably have died of intestinal perforation. Since that time, we never permit the introduction of more than 40 cc of air. I should say that most of these cases were recent obstructions, by which I mean that they occurred during hospitalization following various abdominal operations. These, I think, are the cases in which the method is least likely to get us into trouble because strangulation is unlikely to occur. When the Miller-Abbott tube is successfully introduced, bowel movements will usually occur within 12 hours after it has passed the pylorus. If this does not occur, it is unsafe to continue the treatment without operation because it is probable that the obstruction is of such a character that strangulation is likely to take place.

DR EDWARD V. MASTIN (St. Louis, Mo.) I was very interested in Doctor Henry's paper and would like to report the case of a girl, five and one-half years old, who had had three attacks of acute intestinal obstruction due to intussusception during a period of ten months.

At the first operation the obstruction was relieved and her appendix, which was acutely inflamed, was removed. The ileum was sutured to the side of the cecum. The second attack occurred three months later and required surgery. At this operation it was very difficult to reduce the intussusception and no additional surgery seemed justified as the child was quite ill at the time. The third attack took place seven months later and, at operation, it was found that three and one-half feet of ileum had invaginated into the cecum and ascending colon. After the intussusception was reduced, I split the peritoneum over the lateral portion of the abdominal wall and scarified the cecum with gauze, then sutured it to the lateral abdominal wall with interrupted sutures of silk so that it was thoroughly fixed. It has been a year and eight months since the last operation and the child has had no further attacks of intussusception.

DR M. J. HENRY (Louisville, Ky., in closing) I should like to mention a case in which I used amniotic fluid. The patient was a boy, age 12, upon whom I operated for intestinal obstruction four times within a period of two months.

The first attack of ileus was one year after a simple appendicectomy. It was due to a band of adhesions. The band was excised, and the convalescence was smooth until the twelfth day, when he developed signs of acute intestinal obstruction. This time there were many loops of intestine adherent to one another. These adhesions were freed and before closing the peritoneum 50 cc of "Amfetin" were poured into the cavity. He left the hospital on the fourteenth day after the operation. In a week or so the bowel was again obstructed. Then it was that I had the opportunity to observe the effect of

amniotic fluid upon the peritoneum. The whole cavity looked as if fine white feathers had been scattered in it. No free loops of intestine were seen. The obstruction was due to very dense adhesions at one point. These could not be separated. A resection of about 18 inches of ileum was performed. The anastomosis was the end-to-end type, using a Rankin clamp, and an enterostomy was made above the anastomosis. In a couple of weeks after an uneventful convalescence he had the fourth attack of ileus. This time I was able to overcome the obstruction by merely separating the adhesions. In desperation I again used the amniotic fluid, using 200 cc instead of the 50 cc used previously. He later developed a subphrenic abscess, which required drainage posteriorly. Although the appearance of the peritoneum at the fourth operation for ileus gave promise of further trouble, the boy has been perfectly well during the past three years.

PENETRATING WOUNDS OF THE ABDOMEN*

AN ANALYSIS OF FORTY-SIX PERSONAL CASES

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MEMBERS of the Southern Surgical Association who have previously reported on penetrating wounds of the abdomen and the dates of their publications include Miles,¹ of New Orleans, in 1887, Parker,² of New Orleans, in 1896, McRae,³ of Atlanta, in 1898, Croftoid,⁴ of Memphis, in 1899, Grant,⁵ of Louisville, in 1899, Wysor,⁶ of Clifton Forge, in 1901, Fenner,⁷ of New Orleans, in 1901, Neff,⁸ of Washington, in 1901, Caldwell,⁹ of Cincinnati, in 1905, Gueiry,¹⁰ of Columbia, in 1907, McRea,¹¹ of Atlanta, in 1908, Mason,^{12, 13} of Birmingham, in 1922 and 1923, Bunch,¹⁴ of Columbia, in 1928, Willis,^{15, 16, 17} of Rocky Mount, in 1931 and 1934, Wilson,¹⁸ of Birmingham, in 1934, and Storck,¹⁹ of New Orleans, in 1938. The Charity Hospital in New Orleans, from which the material for this present report was derived, has also been the source of material for the studies on the same subject, which have been made by Miles,¹ Parker,² Fenner,⁷ Matas,²⁰ Loria,^{21, 22, 23} Miller,²⁴ and Storck.¹⁹ Recent publications concerning penetrating wounds of the abdomen—some of which are based on the recent Spanish and current Sino-Japanese wars, include those by Bastos,²⁵ Butler,²⁶ Capuciu,²⁷ Cubbins and Scuderi,²⁸ Culligan,²⁹ Gomez Duran,³⁰ Giloteanu and Gostescu,³² Guillaume-Louis,³³ Jones,³⁴ Kleuschnei,³⁵ Lanzillo,³⁶ Maass,³⁷ Meyer and Shapiro,³⁸ Mitchiner,³⁹ Beigos Ribalta,⁴⁰ Shipley and Hamrick,⁴¹ Taylor,⁴² Gordon-Taylor,⁴³ von Moirini,⁴⁴ Weishub,⁴⁵ and Wright, Wilkinson, and Gaster.⁴⁶

In a previous communication,¹⁹ observations concerning gunshot wounds of the abdomen based on 35 cases managed in civil practice were reported. The present discussion of penetrating wounds of the abdomen is based on 46 cases, including the 35 gunshot wound cases previously reported and, in addition, 11 penetrating stab wounds of the abdomen, one of which resulted from impalement. All cases of known or suspected penetrating wounds of the abdomen which were encountered during the period of this report were subjected to celiotomy with the exception of those patients who, at the time of admission, were moribund as a result of exsanguinating hemorrhage, or irreparable damage of the abdominal wall and viscera resulting from close range shotgun injuries, and those cases in which the elapsed time since injury was so great that interference with already established natural protective barriers was considered inadvisable. Gunshot and stab wounds of the abdomen in which penetration of the abdomen was suspected, but not found when exploratory

* Read before the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

celiotomy was performed, are not included in this report. Figure 1 shows, graphically, the incidence of the injuries according to race, sex, and age.

The weapon with which the gunshot wounds were inflicted was most frequently a pistol, usually of 32 or 38 caliber, but in several instances the weapons were of 44 or 45 caliber. Three wounds were caused by rifle bullets, which, in two instances, were of 22 caliber. In two instances, the wounds were produced by shotgun fire. In all of the stab wound cases, the injuries were inflicted with a knife, except in one instance in which the wound was produced by a stalk of sugar cane, which accidentally penetrated the peritoneal cavity after passing through the anus.

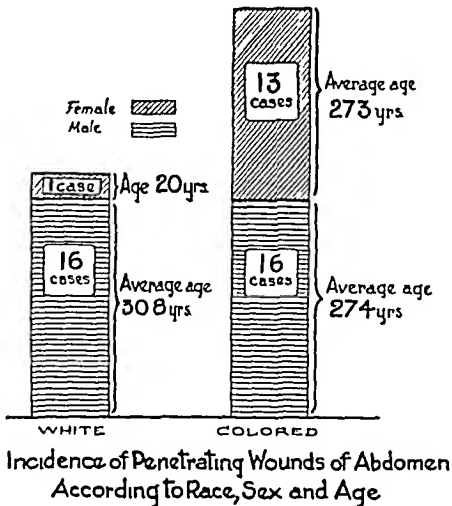


FIG 1.—Graphic representation showing the incidence of penetrating wounds of the abdomen according to race, sex and age.

Details of this latter sort, as well as accurate information concerning the position or physical attitude (*i.e.*, erect, bending over, crouched), of the patient are of value, and, as observed by Meyer and

Shapiro,³⁸ account for the bizarre courses of projectiles, often erroneously ascribed to deflection or ricocheting of bullets.

Most of the gunshot injuries resulted from a single projectile, as was definitely recorded in 29 cases, in two instances, two projectiles entered the abdomen. There were multiple wounds of the abdomen in two cases in which the injuries were inflicted by a shotgun. In the ten stab wound cases in which the number of penetrations was recorded, the patient had been stabbed only once. In ten gunshot cases, there was a single wound of exit, in two cases, there were two wounds of exit, and in the remaining cases, there were no wounds of exit. In none of the stab wound cases was there a wound of exit.

Eighteen of the patients were brought to the hospital by ambulance. One of the fatal gunshot wound cases drove himself to the hospital, the trip requiring three hours. Another patient, in the gunshot wound group, walked three blocks to the hospital. The other cases, with the exception of one fatal case who was transported by police patrol, were brought to the hospital by ordinary passenger automobiles. Transportation of patients with penetrating wounds of the abdomen in properly heated ambulances is obviously the ideal method of transferring such patients unless alarming hemorrhage

makes undesirable the delay which would be involved in summoning the ambulance

The average period elapsed from the time of injury to the time of admission to the hospital for the combined gunshot and stab wound groups was 131 8 minutes, the average period in the survival cases was 140 minutes, whereas in the fatal cases the period was 117 minutes. The longer average duration in the survival cases was due to the transportation over long distances of several patients who were in very good condition. The period elapsed from time of admission until time of operation, which time was required for observation, treatment of shock, or other preparation for operation, was 83 8 minutes, the average period for the survival cases being 65 minutes, whereas, in the instance of the fatal cases, the period was 116 minutes. The average duration from time of injury until time of operation, for the combined gunshot and stab wound cases, was 215 6 minutes, in the survival cases this interval averaged 205 minutes, whereas in the fatal group it was 233 minutes.

Preoperative Symptoms—Abdominal pain was present in many cases, but, frequently, this symptom was remarkably indefinite or practically absent, the pain due to associated injuries was often greater than the abdominal pain. Acute alcoholism in eight cases, seven of which were gunshot wound cases, might have obtunded sensation, but the absence of considerable abdominal pain was repeatedly observed in the instances of patients who had not been drinking. The presence or absence of abdominal pain, certainly, cannot be relied upon as evidence that penetration of the abdominal cavity has or has not occurred. The indications of peritoneal irritation, including abdominal pain, were almost always directly proportional to the amount of blood in the peritoneal cavity or to the amount of spillage from the stomach, small intestine, or gallbladder. Abdominal pain was remarkably absent in the cases with perforations of the large intestine, probably because of the small amount of spillage of solid or semisolid fecal material. Abdominal pain is particularly likely to be absent in gunshot wound cases in which the bullet enters the peritoneal cavity through the gluteal, sacral, or perineal regions, and penetration of the peritoneum is frequently overlooked in such cases. In no instance was it noted that pain was referred to the base of the neck or to the scapular region, even though the amount of blood present in the peritoneal cavity in many instances might have been expected to cause such referred pain.

In several cases, in which there had been massive hemorrhage, the patients experienced an hunger and extreme thirst. Nausea and vomiting were recorded in only three cases, and in no instance was there a record of hematemesis, even though the stomach was perforated in several cases.

Preoperative Physical Findings—The average temperature in the combined groups was 99 2° F, without any considerable difference in the averages for the survival or the fatal cases, although instances of subnormal temperatures were more frequently noted among the fatal cases. The respiratory

rate averaged 25 per minute, without any considerable difference in respect either to range or average in the survival or the fatal cases, the pulse rate for the combined groups averaged 109 per minute, with an average of five pulsations more per minute in the fatal group, and with no considerable difference in the range, *i e.*, 66 to 135 and 68 to 140, in the survival and the fatal groups, respectively

Blood pressures for the combined groups averaged 107/65 Mm Hg, the average in the survival group being 120/67 and in the fatal group 90/62. The range of blood pressures in the survival group was 180/90 to 92/60, while the range in the fatal group was 112/80 to 58/40.

In the combined gunshot and stab wound cases which lived, shock was recorded as slight in two cases, as moderate in one case, and of an unspecified degree in six cases, whereas in the group which died the degree of shock was recorded as moderate in two instances, marked in two instances, and of unspecified degree in five instances.

Abdominal tenderness was recorded in only nine instances in the combined gunshot and stab wound groups, eight of which were gunshot cases. Abdominal rigidity was recorded in 11 cases, only one of the cases in which rigidity was recorded was a stab wound case. The relatively low incidence of recorded tenderness and rigidity was probably due, at least in part, to failure to record these conditions.

Rectal examination revealed varying degrees of tenderness. In the case in which the penetrating wound was produced by a stalk of sugar cane entering the rectum, as well as in some cases of gunshot wounds involving the rectum, rectal examination revealed blood, and in several instances, the perforation could be felt. Vaginal examination in one case revealed distinct tenderness in the fornices.

Abdominal distention was present to a moderate degree at the time of admission in one case. Absence of liver dullness was not recorded in any case in either group, although repeated attempts were made to elicit this evidence of gas or air in the peritoneal cavity. A completely thoracic type of breathing was observed in only one instance, a gunshot wound case with associated spinal cord injury, but respiration with practically no abdominal component was present in several additional cases.

Clinical Laboratory Findings—Examination of the urine for gross or microscopic blood was made in all cases. Hematuria was present to some degree in 15 instances. In seven cases, in which blood was detected microscopically, the red blood cells were reported as few in one instance, many in one instance, and the number was unspecified in five instances. Gross hematuria was observed in three cases. In five cases it was not noted whether the blood was detected grossly or microscopically. A positive Wassermann reaction was obtained in eight cases in the combined groups. Red blood cell counts and hemoglobin index determinations were made in only a few cases, because such examinations are usually of practically no value in determining the management of patients with penetrating wounds of the abdomen. Signifi-

cant lowering of the red blood cell counts and hemoglobin index in the presence of slow and moderate hemorrhage, as well as in sudden massive hemorrhage, is almost invariably preceded by clinical evidences of hemorrhage and shock. Whenever doubt exists concerning the degree or continuance of bleeding, exploratory celiotomy is usually a safer procedure than is prolonged observation of the patient for changes in the red blood cell count or hemoglobin index.

Plasma protein determinations, although not likely to be of particular value in the preoperative estimation of patients with penetrating wounds of the abdomen, may serve as an important therapeutic guide in the postoperative management of such cases. Several methods are now available for rapid estimation of plasma protein levels, including the falling-drop method⁴⁸ and the Bing-bead method⁴⁹.

Roentgenologic Findings—Fluoroscopic or skiagraphic examinations were undertaken in most of the gunshot wound cases. These examinations were made not only to locate bullets but were also made to determine the presence of such conditions as hemopneumothorax and fractures of the extremities. In no instance was the presence of air or gas beneath the diaphragm demonstrated roentgenographically. Exact localization of bullets by one of the several methods available may, at times, be of distinct value in the management of bullet wounds of the abdomen, and exact localization of bullets by the Granger⁴⁷ method was undertaken in several cases in this series.

Associated Conditions—Associated chest injuries were recorded in a total of 11 cases in the combined groups. Two of the gunshot wounds, with associated chest injuries, had an extensive hemopneumothorax. One of the gunshot wound cases, who was five months pregnant, had a penetration of the gastrohepatic omentum and a moderate degree of intraperitoneal hemorrhage; this patient was subsequently delivered of a normal child, without any complications during parturition. Spinal cord injury existed in two gunshot wound cases, and in each instance was manifested by paralysis of the lower extremities which was present at the time of admission. In several cases, there were associated injuries of the head, the neck, or the extremities.

Choice of Cases for Operation and Time of Operation—The preoperative determination of whether or not penetration of the peritoneal cavity has occurred is often difficult, and the fallacy of depending on such factors as the presence or absence of abdominal pain, tenderness, or rigidity to determine whether or not penetration of the abdomen has occurred, has already been referred to. Eisberg⁵⁰ also has observed the inconstancy of the signs and symptoms present in penetrating wounds of the abdomen and, in accordance with Schoenberg,⁵¹ Silleck,⁵² and Winslow,⁵³ he advocates exploratory celiotomy in all doubtful cases. Although it has been contended that penetrating wounds of the abdomen caused by small-sized birdshot do not require exploratory celiotomy, the serious hemorrhage due to injury of important blood vessels, as well as the possible production of gaping lacerated wounds of the intestinal wall which may be produced by such small-sized shot, makes the nonoperative treatment of even such injuries inadvisable.

Eisberg⁵⁰ stresses the importance of the study of the entrance and exit points, and he cites that bullet wounds of entrance are usually smaller than the caliber of the bullet, while the point of exit is more or less keyhole in shape and larger than the wound of entrance. He also draws attention to the fact that "if an area of abrasion and contusion is concentric, it signifies that the bullet has taken a straight course, and that the underlying viscera in this region are, in all probability, injured, if the area is to the right of the edge of the wound, it signifies that the missile has passed from right to left. Since the opposite side of this area is always undermined, and this process, in turn, in-

Types of Wounds in Relation To Direction of Bullets

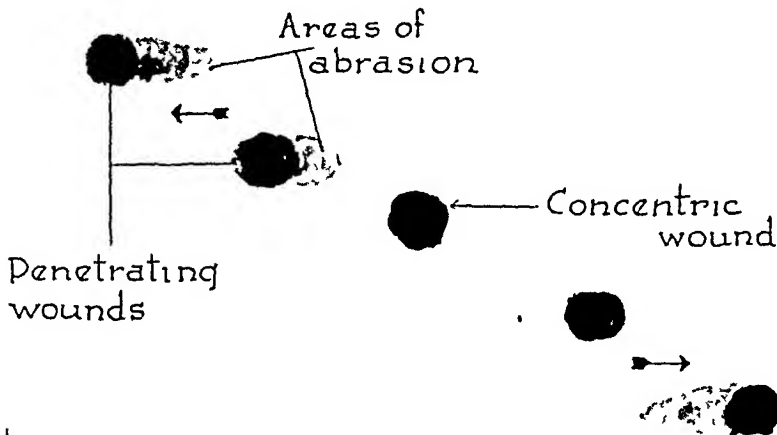


FIG. 2.—Drawing illustrating various types of external wounds in relation to the courses taken by bullets. A concentric area of abrasion and contusion indicates that the bullet has taken a straight course. If the area of abrasion is to the right of the edge of the wound, it signifies that the missile has passed from right to left, and *vice versa* if the area of abrasion is to the left of the edge of the wound. Furthermore, the amount of undermining beneath the edge of the wound opposite the area of abrasion may indicate the obliquity of the course of the missile.

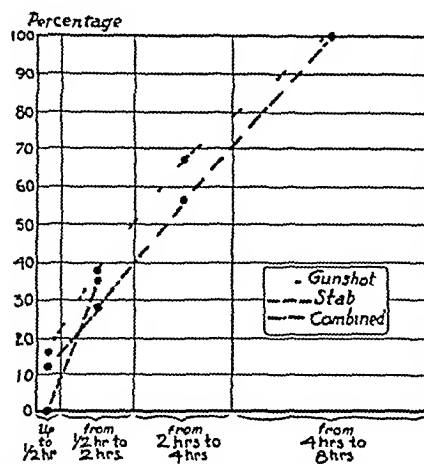
creases with the obliquity, the more superficial the bullet tract the larger the area of abrasion and contusion and the greater the undermining as shown in Figure 2. This observation is very important in differentiating superficial nonpenetrating wounds of the abdomen which cross the abdomen causing pain and at times nausea, vomiting, tenderness and rigidity." Davis,⁵⁴ although observing that rigidity, localized pain, and tenderness on pressure are common symptoms, and that pain is greater, and rigidity usually board-like, when the stomach or intestines are perforated, says that these findings are not always dependable. In the instance of gunshot wounds when the bullet has not made its exit, study of the roentgenographically localized bullet in relation to the wound of entrance is usually of obvious value. Even when it seems unlikely that penetration of the abdominal cavity has occurred, the possibility of the bullet having ricocheted after penetrating the skin and subcutaneous tissue as well as the effect of the position of the patient or the influence of respira-

oily movement on the course of the bullet, as pointed out by Meyer and Shapiro,³⁸ must be kept in mind. Unexpected and unpredictable visceral injuries were found in several cases in the present series.

It was often difficult to determine the optimal time for operation, and, although it was frequently impossible to improve the patient's condition to the desired degree before operation, celiotomy was performed as soon as the patient's condition was sufficiently good to permit abdominal exploration. Oberhelman and LeCount,⁵⁵ on the basis of a review of the literature and a study of 343 cases treated at the Cook County Hospital, expressed the belief that "perhaps the most important element aiding the recovery of patients with bullet wounds of the abdomen is a short interval between the injury and the operation." Realizing the irreversible deleterious effects produced by prolonged shock, and recognizing the importance of rapid preparation for operation of patients with penetrating wounds of the abdomen, as emphasized by Condict,³⁶ and at the same time appreciating the advisability of avoiding operation in the presence of profound or even considerable shock, rapid preparation of the patients for operation was attempted in all cases. However, the intentional delay of operation for several hours seemed advisable in several instances. When there was no evidence of considerable shock, operations were undertaken promptly, to avert the possible development of shock from continued slight bleeding or subsequent massive hemorrhage.

The decision concerning the advisability of operation in cases of relatively long duration is frequently difficult. Although it is impossible, on the basis of elapsed time alone, to arbitrarily fix a late time limit for operability, natural protective barriers such as fibinous exudate and adhesions, as well as the edema which often results in the sealing off or closure of hollow visceral injuries, have usually become well established within 12 or 14 hours following injury. In the instance of penetrating wounds involving only the upper abdomen, the period during which operation is advisable may be considerably extended because, in upper abdominal injuries, not only is continued hemorrhage from the liver or spleen likely to make even late operation necessary, but the absence of, or smaller number of perforations of hollow viscera in such cases makes late operation relatively safe.

The consistent direct relationship between the mortality and the duration from time of hospital admission to operation (Chart 1) not only emphasizes the advisability of performing celiotomy as soon as the patient's condition per-



Mortality in Relation to Duration
From Time of Admission to Operation

CHART 1.—Curve indicating the mortality in relation to the period elapsed from the time of admission to the hospital to the time of operation. The form of this curve is, in part due to the good condition of those patients upon whom early operation could be performed without considerable preoperative preparation.

mits, but the form of this curve is actually the result of the relatively good condition of the patient upon whom early operation was performed. The higher mortality rate in the instance of cases in which there was a long period between the time of admission and operation was not due to the prolongation of this period either by choice, or through neglect to expedite preoperative

preparation or to perform early operation, but was due to the fact that the poor condition of these patients necessitated prolonged preoperative preparation in an attempt to prepare them to withstand operative intervention.

Chart 2 graphically indicates the influence of shock and hemorrhage upon the mortality in penetrating wounds of the abdomen. The comparatively low mortality in the cases admitted to the hospital from one-half hour to two hours following injury suggests that patients in this group were either suffering from a less severe degree of shock and hemorrhage, or that considerable recovery from these conditions had occurred before celiotomy was performed. The higher mortality in the group of cases who were admitted to the hospital within half an hour following their injury, although probably partly due to the seriousness of the injuries or to primarily severe shock and hemorrhage, was probably to some extent the result of the performance of celiotomy at a time when some of the patients in this group were still suffering from considerable shock or hemorrhage. The recovery of all patients whose admission to the hospital was delayed for from eight to 12 hours is presumably due to the fact that these patients did not have extremely serious injuries, that they were not suffering from massive hemorrhage and that they had either never suffered from or had recovered from shock. The high mortality in the group of patients admitted within four to eight hours following their injury may be considered to be the result of the deleterious effect of prolonged shock and arterial hypotension.

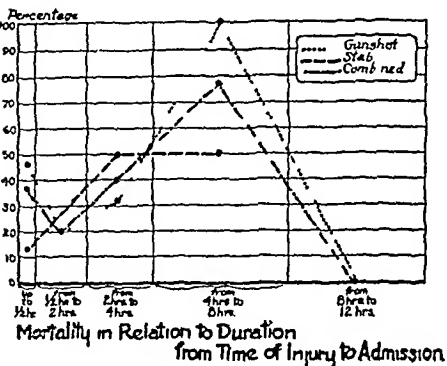


CHART 2.—Curve showing the mortality in relation to the period of time elapsed from the time of injury to the time of admission. The forms of the curves reflect the influence of shock and hemorrhage and emphasize the value of the early institution of measures to combat these conditions. The comparatively low mortality in the cases admitted to the hospital from one-half to two hours following injury suggests that patients in this group were either suffering from a less severe degree of shock and hemorrhage or that considerable recovery from these conditions had occurred before celiotomy was performed. The higher mortality in the group of cases who were admitted to the hospital within half an hour following their injury, although partly due to the seriousness of the injury or to primarily severe shock and hemorrhage, was probably to some extent the result of the performance of celiotomy at a time when some of the patients in this group were still suffering from shock or hemorrhage. The recovery of all patients whose admission to the hospital was delayed for from eight to 12 hours is presumably due to the fact that these patients did not have extremely serious injuries, that they were not suffering from massive hemorrhage and that they had either never suffered from or had recovered from shock. The high mortality in the group of patients admitted within four to eight hours following their injury may be considered to be the result of the deleterious effect of prolonged shock and arterial hypotension.

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Preoperative Preparation, Including Preanesthetic Preparation—When patients were first seen, measures to combat shock were instituted immediately. In addition to the application of external heat and elevation of the foot of the bed, morphine sulphate was administered in appropriate large doses

In the instance of patients who were considerably intoxicated at the time of admission, oxygen was administered by inhalation, and was usually effective in considerably sobering these individuals

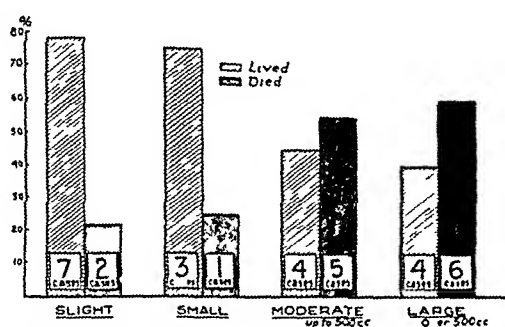
The importance of sometimes administering preoperative transfusions of as much as 2,000 to 3,000 cc of blood within the first 24 hours following penetrating injury of the abdomen, the difficulties of obtaining blood for this class of cases, and the improved methods now available for storing blood, have been discussed in a previous communication,¹⁹ which included a consideration of various methods of transfusion, and indicated the dangers of autotransfusion of blood obtained from the abdominal or thoracic cavities. The relationship between the degree of hemorrhage and the mortality in the present gunshot wound cases, as shown in Figure 3, has also been referred to by Mason,^{12, 14} Loria,²³ and others, and in addition emphasizing the importance of adequate preoperative transfusion, indicates the advisability of first directing attention during operation to the detection of bleeding points and the arrest of hemorrhage.

Eleven patients were given fluids by infusions or hypodermoclyses, which usually consisted of 1,000 cc of 5 to 10 per cent glucose, and normal to 2 per cent saline solution, or lactated Ringer's solution. When glucose solution of more than 5 per cent is employed, it is considered advisable to counteract the peristaltic inhibiting effect of such solutions by the administration of appropriate amounts of insulin, as suggested by the observations of Ochsner, *et al*.⁵⁷ In general, the administration of fluids in the form of blood transfusions rather than infusions is particularly desirable in those cases in which continuing hemorrhage is evident or suspected.

A 3,000 unit prophylactic dose of antitetanic serum was given to all gunshot cases, and at least 1,500 units were given to all stab wound cases. Mixed antianaerobic serum was administered to three of the gunshot wound cases, and one of the gunshot wound patients received perfringens antitoxin.

Stimulant drugs, including caffeine sodium benzoate and adrenalin, were administered preoperatively to six cases. All of the patients to whom it was considered necessary to administer stimulants preoperatively, died. Although there may be occasional indication for the use of so-called stimulant drugs, benefit is more likely to follow the infusion of solutions of sodium chloride, glucose, or acacia, blood transfusion, or the placing of the patient in the head-down position.

Preoperative catheterization was performed when patients were unable to void, both for the purpose of obtaining a specimen of urine for examination



Mortality in Relation to Degree of Hemorrhage

FIG 3—Graphic representation showing the direct relationship between the degree of hemorrhage and the mortality. Comparison of Figure 3 with Figure 4 which latter figure shows the average number of visceral perforations in relationship to mortality, reveals how much more important is the relationship between hemorrhage and mortality than is the relationship between the number of perforations and mortality.

and of being assured that the bladder would be empty at operation. In three instances of injury involving the urinary tract, preoperative cystoscopy and introduction of ureteral catheters was done.

In order that operation might be started as soon as shock was sufficiently combated, some of the patients were immediately sent to the operating room for preoperative observation and preparation, thereby avoiding moving of the patients on and off carriers and in and out of bed.

The respiratory stimulating effect of scopolamine, referred to by Waters,⁵⁸ suggests that this drug, rather than atropine, should be employed for pre-anesthetic preparation purposes.

TABLE I
MORTALITY IN RELATION TO ANESTHESIA

	ETHER	ETHYLENE	SPINAL & ETHYLENE	SPINAL & ETHER	SPINAL	LOCAL	LOCAL & ETHER
GUNSHOT							
Lived	10	2	1	1	6	0	1
Died	13	0	0	0	0	1	0
SIAB							
Lived	1	1	0	0	4	2	0
Died	1	1	0	0	0	1	0
COMBINED							
Lived	11	3	1	1	10	2	1
Died	14	1	0	0	0	2	0

Table I shows the mortality in relationship to the type of anesthesia. The absence of any deaths when spinal anesthesia was employed, either alone or in combination with ethylene or ether is remarkable even though the cases in which spinal anesthesia was employed were those in which there was not a pronounced preoperative depression of the blood pressures. The high mortality when either ether or local anesthesia was used was due to the practice of employing these anesthetics for those patients who manifested the greater degrees of shock and hemorrhage.

The higher mortality when either ether or local anesthesia was employed was unquestionably due to the practice of employing these anesthetics for those patients who manifested the greater degrees of shock and hemorrhage. The relatively high concentration of oxygen which may be maintained in the anesthetic mixture when cyclopropane is employed as an anesthetic agent makes this form of gas anesthesia particularly desirable in some cases of penetrating wounds of the abdomen.

Attention to the Patient on the Operating Table, Aside from the Principal Operative Procedure—Despite the preoperative institution of measures to combat shock, some degree of shock was frequently still present when the operation was begun, so that the continuation of shock therapy was sometimes necessary or had to be instituted in the operating room. Frequent determinations of the pulse rate and the blood pressure were made during the patient's stay in the operating room, both for the purpose of serving as a guide to the administration of fluids or stimulants, and because of the value of these determinations in indicating permissible operative procedure. The upper end of the operating table was sometimes kept lowered as much as 30° during the operation.

Anesthesia—The choice of the anesthetic was, in each case, based upon the patient's preoperative condition, the presence or absence of chest or other extra-abdominal injury, and the extent of operative procedures estimated to be necessary. The frequency with which various types of anesthetics were employed and the mortality according to the anesthetics used are shown in Table I. The absence of any deaths when spinal anesthesia was employed, either alone or in combination with ethylene or ether, is remarkable, even though the cases in which spinal anesthesia was employed were those in which there was not a pronounced preoperative depression of

Type of Incision—The type of incision varied greatly, being determined by such factors as the site of the wound of entry, the location of the wound of exit, or the position of bullets which could be felt or detected either roentgenographically or by fluoroscopic examination. Rectus abdominis muscle-splitting incisions were most frequently employed in order to save time in entering the abdomen and to minimize the amount of separation of the rectus abdominis muscle from its sheath.

Findings at Operation—As previously indicated, the ricochet of bullets and the displacement of viscera by respiration, as well as variations in the relative position of parts of the patient's body as compared with the position of the same parts on the operating table, accounted for unexpected and unpredictable visceral injuries in several instances. The opening of the peritoneal cavity was never accompanied by the hissing sound sometimes heard in cases of perforated peptic ulcer in which there is considerable gas in the abdominal cavity. The failure to find gas under pressure in the peritoneal cavity at the time of operation might have been due to the previous escape of gas through abdominal wall perforations.

The quantity of either liquid or clotted blood in the peritoneal cavity varied greatly. Accurate determination of these amounts was practically impossible because, in addition to the volume collected in suction apparatus jars, at least some of the blood was always removed in the form of clots or by means of sponges. When the hemorrhage was massive, liquid blood sometimes poured out of the wound before it could be collected and measured.

Extraperitoneal hemorrhage was found in a number of the gunshot wound cases, and was perivesical in one case, retrovesical and perinephritic in one case, retroperitoneal in four cases, retosigmoid in three cases, perineal in two cases, and of unspecified location in one case. In the 12 cases in which there was some type of extraperitoneal hemorrhage, there were seven survivals and five fatalities. Estimates of the amount of extraperitoneal hemorrhage are likely to be very inaccurate, and such estimates were not attempted.

Bullets lodged in the subcutaneous tissue or superficially situated in muscle tissue were removed at the time of operation in four cases. In one instance, a bullet was found lying free in Morrison's pouch. Bullets which were not readily located or easily removable at the time of operation were usually removed several days later, under local anesthesia.

Spillage of a considerable amount of intestinal contents was recorded in only six cases, all of which were gunshot wound cases which survived. This apparent paradox is evidently due to the fact that in every case in which considerable spillage was recognizable, the amount of hemorrhage was slight, thereby permitting recognition of the spillage as well as favoring recovery.

The total number of perforations of either solid or hollow viscera was only slightly less in the group which lived than in the group which died. In the survival cases there was an average of 5.33 perforations per patient, with a maximum of 25 perforations in a single case, whereas in the fatal cases

there was an average of 5.71 perforations per patient, with a maximum of 18 perforations in a single case. The lack of a distinct relationship between the number of perforations and the mortality (Fig. 4) is noteworthy, in contrast with the close relationship existing between the amount of hemorrhage and the mortality (Fig. 3).

Stomach perforation occurred in six cases. In four instances, the stomach injuries were the result of gunshot wounds and were in each instance associated with injury of other viscera. In two instances, the stomach injury resulting from gunshot wounds was associated with injury of the liver. As previously mentioned, there was no record of hematemesis in any case. In one instance, two stomach perforations were associated with perforations of

Average Number of Perforations
in Relation to Mortality

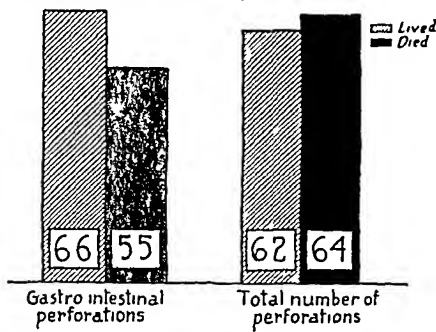


FIG. 4.—Graphic representation showing the average number of visceral perforations in relationship to the mortality. Comparison of this figure with Figure 3 reveals the fact that the degree of hemorrhage is more directly related to the mortality in penetrating wounds of the abdomen than is the number of perforations.

the jejunum. In another gunshot case, a stomach perforation was associated with perforation of the transverse colon as well as the jejunum. In the stab wound cases, stomach injury occurred in two instances. In one of these latter cases there was associated evisceration of the stomach. The other patient had two perforations of the stomach. Whenever wounds involving the anterior wall of the stomach were found, the lesser peritoneal cavity was entered and the posterior surface of the stomach was examined for the wound which is to be anticipated in that region, particularly in the instance of gunshot wounds. Instead of dividing the gastro-

colic or gastrohepatic omenta for the purpose of revealing or permitting repair of wounds on the posterior wall of the stomach, satisfactory exposure and repair may be accomplished by enlarging the wound located in the anterior stomach wall, as suggested by Pley and Foster.⁵⁹

Duodenal injury was not found in any case in this series. Because injuries to the duodenum may be easily overlooked, and because of the importance of accurate closure of such injuries, thorough search for duodenal wounds was made, especially when injuries were located in the upper abdomen.

Injury to the jejunum was specifically recorded in seven gunshot wound cases, and in all but one of these patients there were associated injuries of other viscera, thus probably accounting for the survival of only four of these individuals. The patient in which there was jejunal injury alone, lived. The jejunum was eviscerated in two stab wound cases and in one instance there was an associated incised wound of the jejunum, the former patient lived and the latter died. Although a favorable prognosis might be expected because of the character of the bacterial flora of the jejunum, a relatively high mortality, such as occurred in the present cases, has been reported by others.

Injuries of the ileum were specifically recorded in 12 gunshot wound cases, with eight survivals and four fatalities. In one stab wound case, perforation of the ileum was associated with partial evisceration of the ileum, this case survived. This relatively high survival rate among patients with injury of the ileum is particularly remarkable since in all but one instance the injuries to the ileum were associated with injury of one or more other viscera, such as the colon, cecum, rectum, jejunum, ureter, uterus, or bladder.

Perforation of the cecum occurred in four of the gunshot wound cases, all of which lived. Except for the fact that there was a relatively small amount of hemorrhage in three of these cases, the absence of any mortality accompanying injuries to the cecum would be especially surprising, since in three instances there were associated perforations of the ileum and in one instance perforation of the rectum. In no case in this series was there injury to the appendix, although in one of the gunshot wound cases there was injury to the mesoappendix, which necessitated appendectomy.

The ascending colon was injured in one gunshot wound case and this patient lived, although his convalescence was prolonged by the development of an extensive abdominal wall infection. Transverse colon perforation occurred only once, this patient, who had associated stomach and jejunal perforations, died. The transverse colon was eviscerated in two of the stab wound cases, but in neither instance was it perforated, both these patients lived. The descending colon was injured in the region of the splenic flexure in one gunshot wound case in which there was also considerable retroperitoneal hemorrhage, this patient died. The sigmoid colon was injured in five cases. One patient, with a perforation of the sigmoid and associated lacerated perforations of the jejunum, lived, two patients with perforations of the sigmoid and two patients with contusions of the sigmoid died. The four latter sigmoid injuries were associated either with small bowel or liver penetrations, or with considerable hemorrhage.

The rectum was perforated in four cases. Three of these injuries were gunshot wounds, and two of the patients lived, whereas one died. In all of the gunshot wound injuries of the rectum, the bullet entered through the buttocks. When the wound of entry is so located, the possibility of intraperitoneal injury is frequently overlooked and the intraperitoneal entrance of the bullet may not be recognized until signs of localized or diffuse peritonitis become apparent. It has even happened that patients with gunshot wounds of the buttocks have been discharged from the hospital before intraperitoneal injury was recognized, only to be rehospitalized several days later when definite evidence of peritonitis had developed. The other case in this series in which perforation of the rectum occurred, was one in which a stalk of sugar cane accidentally entered the anus, and caused perforation of the anal canal, the rectum, and the neck of the bladder, this patient survived.

The relatively low mortality rate in the group of cases with large intestine injury was strikingly at variance with the generally conceded seriousness of large intestine injuries, and was probably due to the relatively small quantity

of spillage which ordinarily accompanies such injuries, as well as to the tendency of the relatively solid large intestine content which does escape, to remain localized.

Perforation of the gallbladder in the region of its neck occurred in one gunshot wound case, while in another gunshot wound case there was injury of the common bile duct associated with injury to the pancreas, jejunal mesentery, and spinal cord, both of these patients died.

Injuries to the ureter, kidney, bladder or prostate occurred in ten instances. In most of the cases with urinary tract injury, the existence of the lesion was suspected because of the location or direction of the gunshot or stab wounds. In several instances, however, unsuspected urinary tract injuries were revealed as a result of routine examination of the urine for gross or microscopic blood. The kidney was injured in three cases in the gunshot wound group, in two instances the injuries were located in the upper pole of the kidney, and were followed by survival in one instance and death in the other, the third case had an injury of the kidney in the hilar region, and this patient died. Injury to the kidney occurred in one stab wound case, this patient lived. Kidney injuries are particularly serious, and there is no efficient method of dealing with them. The retroperitoneal location of the kidneys, and the large retroperitoneal hematomata, usually associated with injuries to the kidneys, frequently make it impossible to accurately determine the location and extent of the injury. Under such circumstances, exposure of the renal blood vessels is extremely difficult, and either transperitoneal nephrectomy, after mobilizing the mesocolon, or removal of the kidney through a separate lumbar incision involves dangerous additional trauma and prolongation of the operation. Injury of the left ureter was present in one of the gunshot wound cases and was associated with moderate retroperitoneal hemorrhage extending between the leaves of the descending colon and sigmoid mesenteries, this patient lived.

Injury to the bladder occurred in five cases in the gunshot wound group. In two instances, these injuries were contusions or incompletely penetrating injuries of the bladder wall, both of these cases, in one of which there was considerable perivesical hemorrhage, survived following plication of the bladder wall. One case in which perforation of the bladder was associated with perforation of the prostate survived. Of the remaining two gunshot wounds of the bladder, both of which were perforating wounds, one was accompanied by considerable extravasation of urine, both of the latter cases died. In one of the stab wound cases, perforation of the vesical neck was associated with perforation of both the prostate and the rectum, this patient survived.

Perforation of the uterus occurred in one gunshot case and was associated with hemorrhage into the broad ligament. This patient lived following closure of the uterine perforation and ligation of bleeding points in the broad ligament.

The diaphragm was injured in one stab wound case, in which there was associated chest perforation caused by the same stab wound. In this case, the twelfth rib was resected and, following peritoneal exploration through

the opening in the diaphragm, transpleural repair of the diaphragm was effected, the patient lived. In none of the gunshot wound cases was the diaphragm injured.

Injury of the liver occurred in nine cases, and was the result of a gunshot wound in every instance. In six cases, the injuries of the liver were accompanied by injuries to other important viscera, five of these patients lived while four died. In seven cases, the injury was limited to the right lobe, in one instance, there was injury of both the right and the left lobes, in the remaining case, the site of the liver injury was not recorded. In five instances, the character of the wound was stellate or lacerated, and in one instance a furrowed wound involved the lower surface of the right and left lobes, the rest of the wounds were punctate. In the nine gunshot wound cases in which injury to the liver occurred, there were, in three instances, no associated lesions, and of these patients, two lived and one died, while in the six cases with associated injuries to other viscera there were three deaths and three survivals. Blood clots which had formed between liver lacerations were usually not disturbed because of the bleeding which usually follows their removal. In none of the stab wound cases was the liver injured.

Spleen injuries occurred in three gunshot wound cases, but injury to this organ was not observed in any of the stab wound cases. In one instance, the perforation was located in the upper half of the spleen while in two instances the injury occurred through the lower pole, two of these patients lived. In the fatal case, a punctate wound involved the lower pole of the spleen. A moderate to a large amount of hemorrhage was associated with the injuries to the spleen. Two of the three cases lived without splenectomy being performed. The third case had an accompanying kidney perforation which may have played an important part in causing death. It is probably usually advisable to perform splenectomy, if the injury of the spleen is a lacerated one or if it is located near the hilum of the spleen. However, if the patient's condition is extremely poor, if there are many associated hollow visceral injuries, if the spleen wound is punctate and located away from the hilum, and if no bleeding from the spleen is occurring at the time of operation, it is sometimes better not to perform splenectomy.

The pancreas was injured in only one case. This injury, which occurred in the region of the head of the pancreas, was associated with injury of the spinal cord, the common bile duct, and the jejunal mesentery. Death occurred several days following exploration and the introduction of drains which extended down to the site of the injury to the pancreas and the bile ducts. The outcome following a gunshot injury of the pancreas is largely dependent upon whether or not one or both of the principal pancreatic ducts have been injured, and upon the character of the associated injuries. Transplantation of the pancreas or the pancreatic ducts into the small intestine is usually not feasible in the instance of patients who have penetrating wounds of the abdomen.

TABLE II

GUNSHOT WOUNDS

SHOWING THE SEX, AGE, COLOR, NUMBER AND SITE OF EXTERNAL WOUNDS, DURATION FROM TIME OF INJURY UNTIL OPERATION, ASSOCIATED INJURIES AND OTHER FINDINGS, SYMPTOMS AND PHYSICAL FINDINGS, FINDINGS AT OPERATION, OPERATIVE PROCEDURE, AND THE OUTCOME OF THE CASES IN THE PRESENT SERIES

Initials and Case No	Sex	Age	Color	Number and Site of External Wounds	Duration from Time of Injury until Operation	Associated Injuries and Other Findings	Symptoms and Physical Findings	Findings at Operation	Procedure	Result
M B 1	M	25	C	1 (entrance) below and to right of umbilicus	2 hrs 30 mins	Contusion of scalp Positive Wassermann	Nausea, B P 128/70, P 90, T 100 R 26 Abdominal rigidity B P 130/70, P 116, T 99.5, R 22 Vaginate shock Abdominal rigidity P 126 R 28 Slight shock Abdominal rigidity	Contusion of bladder 3 perforations of ileum, perivesical hematoma Lacerated wound of dome of liver, old omental adhesions, moderate amount of hemorrhage 22 perforations of jejunum and ileum and 3 of small intestinal mesentery, moderate amount of hemorrhage One perforation of ascending colon, slight amount of hemorrhage Retroperitoneal hemorrhage one perforation of descending mesocolon 2 perforations of stomach 2 of jejunum (1 lacerated), small amount of hemorrhage Penetrating wound of upper posterolateral portion of liver, large amount of hemorrhage	Ileorrhaphies (3) plication of bladder Exploration evacuation of liquid blood and clots division of omental adhesions Enterorrhaphies (22) Colorrhaphy (1) Gastrorrhaphies (2) suture of mesocolon, jejunorrhaphies (2) Exploration, removal of clots and liquid blood introduction of pack	L L L L
A B 2	M	38	W	1 (entrance) lower anterior chest	3 hrs 20 mins	Gunshot wound of chest with hemopneumothorax				
Q B 3	M	11	W	1 (entrance) below left anterior costal border 1 (exit) below and to right of umbilicus	4 hrs 30 mins					
T C 4	M	37	W	1 (entrance) right upper quadrant	50 mins					
C D 5	M	21	W	1 (entrance) below left costal margin	1 hr 35 mins		B P 130/80 P 135 Abdominal tenderness and rigidity			
F D 6	M	13	W	1 (entrance) right eighth midaxillary 1 (exit) to left of midline 2 inches below xiphoid	1 hr 30 mins	Perforation of right chest, superficial wound of right arm	B P 92/60, P 96, R 22 Shock			

PENETRATING WOUNDS OF ABDOMEN

E I 7	I 21	C	1 (entrance) 2 inches below lower right costal margin in midclavicular line	12 hrs	10 mins	Compound gunshot fracture of left finger	Very slight shock	Abdominal tenderness and rigidity	Turrowing wound inferior surface right and left lobes of liver, perforation of upper half of spleen and gastrohepatic meso, slight hemorrhage	Exploration, suture of gastrophagic omentum, debridement of hand	L
J G 8	M	C	1 (entrance) left tenth interspace in anterior axillary line	4 hrs	20 mins	Abrasion of left upper eyelid	B P 130/70, P 66, R 22 Shock	B P 95/60	Perforation of lower pole of spleen, slight amount of hemorrhage	Exploration, removal of liquid blood and blood clots	L
R H 9	M	26	1 (entrance) 1/2 inch medial to left anterior superior iliac spine	70 mins					11 perforations of ileum, cecum, slight amount of hemorrhage	11 perforations of ileum, cecum, slight amount of hemorrhage	L
E J 10	I 20	C	1 (entrance) left upper per abdomen	60 mins					10 perforations of ileum, cecum, slight amount of hemorrhage	10 perforations of ileum, cecum, slight amount of hemorrhage	L
E J 11	I 22	C	1 (entrance) right anterior costal border and 1 (exit) right lumbar	55 mins	Positive Wassermann	Shock			Slight abdominal tenderness	Slight abdominal tenderness	L
W J 13	M 23	C	1 (entrance) right buttock	60 mins					10 perforations of ileum, cecum, slight amount of hemorrhage	10 perforations of ileum, cecum, slight amount of hemorrhage	L
J I 14	M 22	C	1 (entrance) buttock with 1 (exit) to left and below umbilicus	3 hrs					Rupture of perivesical veins 7 perforations of ileum, contusion of bladder, slight amount of hemorrhage	Rupture of perivesical veins 7 perforations of ileum, contusion of bladder, slight amount of hemorrhage	L
I O R 15	I 20	W	1 (entrance) just below and left of xiphoid and 1 (exit) 2 1/2 inches to left of third lumbar vertebra	2 hrs	Positive Wassermann "Injury" to palm right hand				Perforation of rectum and bladder	Perforation of rectum and bladder	L
				5 months' pregnancy					17 perforations of ileum	17 perforations of ileum	L
									1 lacerated wound of cecum, 1 perforation of rectum, slight amount of hemorrhage	1 lacerated wound of cecum, 1 perforation of rectum, slight amount of hemorrhage	L
									1 gastrohepatic perforation moderate amount of hemorrhage	1 gastrohepatic perforation moderate amount of hemorrhage	L
									Proctorrhaphy (1), cystorrhaphy (1), supra pubic cystotomy	Proctorrhaphy (1), cystorrhaphy (1), supra pubic cystotomy	L
									11 gastrohepatic perforation moderate amount of hemorrhage	11 gastrohepatic perforation moderate amount of hemorrhage	L
									Exploration, suture of gastrophagic omentum, removal of blood clots	Exploration, suture of gastrophagic omentum, removal of blood clots	L

GUNSHOT WOUNDS (Continued)

Initials and Case No	Sex	Age	Color	Number and Site of External Wounds	Duration from Time of Injury until Operation	Associated Injuries and Other Findings	Symptoms and Physical Findings	Findings at Operation	Procedure	Result
L M 16	F	49	C	1 (entrance) left sixth anterior intercostal space	2 hrs 20 mins	"Injury" to right breast	B P 115/80, P 120, R 26 Shock Abdominal tenderness	2 perforations of anterior surface of stomach 2 perforations of liver large amount of hemorrhage	Hepatorrhaphies (2), gastrorrhaphies (2)	L
W M 17	M	29	W	(Multiple) above and over crest of ileum	3 hrs		P 108 Shock Abdominal rigidity	Retropertitoneal hemorrhage extending between leaves of sigmoid and descending mesocolon, laceration left ureter 3 perforations of ileum, slight hemorrhage	Ileorrhaphies (3) introduction of ureteral catheter	L
S W 18	M	28	C	1 (entrance) near and to right of umbilicus	3 hrs 20 mins		B P 108/80, P 96, R 26	Very slight hemorrhage	Ileorrhaphies (3), introduction of ureteral catheter	L
C L 19	F	25	C	2 (entrance) through abdominal wall and 2 through thigh	12 hrs 40 mins	2 gunshot wounds of right thigh	B P 126/80 Abdominal tenderness and rigidity	Extrapertitoneal hemorrhage, 2 perforations of ileum subserous hematoma of cecum laceration of mesoappendix, perforation of fundus of uterus with hemorrhage into broad ligament large amount of hemorrhage	Ileorrhaphies (2), appendectomy, cecostomy (1)	L
D R 20	M	19	C	1 (entrance) left buttock and 1 (exit) left anterior abdominal quadrant	1 hr 15 mins			Extrapertitoneal hemorrhage 2 lacerations of jejunum, 2 perforations of sigmoid 1 perforation of omentum small amount of hemorrhage	Sigmoidorrhaphies (2) jejunorrhaphies (2) closure of laceration of omentum	L
F M 21	M	41	C	1 (entrance) below and to left of umbilicus	1 hr	Positive Wassermann Sliding left inguinal hernia	B P 106/60	Retrosigmoid hematoma 3 lacerations of jejunum, 1 perforation of jejunal and sigmoid mesentery, moderate amount of hemorrhage	Jejunorrhaphies (3) ligation of mesenteric lacerations, hernioplasty	L

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W deJ 22	M	26	W	1 (entrance) just below umbilicus	3 hrs 15 mins	Pain in right chest and abdomen, abdominal rigidity Shock	Right perinephritic hematoma, extensive lacerations of dome and posterior surface of liver, moderate amount of hemorrhage	Exploration and introduction of drain	D
J F 23	M	16	W	1 (entrance) site not recorded	8 hrs 10 mins	P 121, T 101 S, R 21 Pain in lower right abdominal quadrant	Exploration of urine, perforation of rectum, small amount of hemorrhage	Exploration and introduction of drain, suprapubic cystostomy	D
E G 24	M	26	C	"Multiple wounds"	6 hrs 15 mins	Multiple wounds of right forearm	Perforation of ileum, perforation of bladder, large amount of hemorrhage	Exploration and introduction of drain, suprapubic cystostomy, ileostomy	D
S H 25	F	45	C	Not recorded	1 hr 30 mins	Wound of right forearm	Left perinephritic hematoma, 2 lacerations of stomach, multiple lacerations of jejunum, contusion of sigmoid, laceration of liver, laceration of gastroduodenal omentum, laceration of omentum, large amount of hemorrhage	Ileorrhaphies (15), cystorrhaphy, suprapubic cystostomy, ileostomy	D
V T 26	F	16	C	1 (entrance) right upper quadrant of abdomen	2 hrs	Injury to spinal cord	Gastrorrhaphies (2), Murphy resection of jejunum, repair of omentum, plication of sigmoid gauze packs to liver lacerations		D
M M 27	F	23	C	2 (entrance), 1 (exit), sites not recorded	7 hrs 20 mins	Positive Wassermann spinal cord injury	Perforation of bile duct, perforation of pancreas mesentery, slight amount of hemorrhage	Exploration and introduction of drains to resection of bile duct and pancreas perforations	D
E W 28	M	23	C	1 (entrance) first sacral vertebra, 1 1/2 inches to right of midline	1 hr	B P 112/68, P 133 T 101, R 10 Abdominal tenderness and rigidity P 100, T 101, R 24 B P 96/70, P 88, T 96, R 20 Severe abdominal pain Marked shock	Retrosigmoid hematomy, laceration of sigmoid, slight amount of hemorrhage Several lacerations of ileum, 2 perforations of sigmoid, perforation of ileal and sigmoid mesentery, large amount of hemorrhage	Exploration, sigmoidorrhaphy, removal of bullet	D
							Resection 4 inches of ileum, sigmoidorrhaphies (2), removal of bullet, ligation of mesenteric perforations		

GUNSHOT WOUNDS (Continued)

Initials and Case No	Sex	Age	Color	Number and Site of External Wounds	Duration from Time of Injury until Operation	Associated Injuries and Other Findings	Symptoms and Physical Findings	Findings at Operation	Procedure	Result
M Y 29	F	21	C	1 (entrance) right costal margin 1 (entrance) 1 inch above and to right of umbilicus	1 hr 10 mins	Gunshot wounds left buttock, forearm and shoulder "Chest" injury	P 100 Severe abdominal pain, tenderness and rigidity Moderate shock B P 58/40, P 104 R 12 Severe shock	Perforation near neck of gallbladder, perforation of right lower lobe of liver moderate amount of hemorrhage	Exploration cholecystorraphy, cholecystostomy	D
W R 30	M	28	W	1 (entrance) above and to left of umbilicus, 1 (entrance) below and to left of umbilicus	2 hrs 20 mins	Gunshot wounds left buttock, forearm and shoulder "Chest" injury	B P 58/40, P 104 R 12 Severe shock	3 perforations of jejunum, 5 perforations of ileum 6 perforations of ileal and jejunal mesentery, moderate amount of hemorrhage	Ileorhaphies (5) jejunorhaphies (3) suture of mesenteric perforations (6)	D
M R 31	M	42	W	1 (entrance) left midaxillary line at seventh interspace, 1 (exit) 1 inch to right of midline posteriorly at twelfth thoracic vertebra	6 hrs 50 mins	"Chest" injury	B P 105/80, P 108, R 28 Shock	Perforation of left kidney perforation lower pole of spleen moderate amount of hemorrhage	Exploration, removal of blood clots and liquid blood, ureteral catheterization	D
G R 32	M	22	C	Not recorded	6 hrs 30 mins		P 142 Shock	1 perforation of stomach 3 lacerations of jejunum, 1 perforation transverse colon, perforation of jejunal mesentery, moderate amount of hemorrhage	Gastrorrhaphy resection of jejunum, enterorrhaphy colorrhaphy (1)	D
J S 33	M	36	W	1 (entrance) below costal margin in posterior axillary line	2 hrs 20 mins	Gunshot wounds of right shoulder area, left forearm	B P 92/58, P 68, T 97 R 18 Shock	Retropertoneal hematoma 1 perforation of splenic flexure of descending colon, continuation of sigmoid, moderate amount of hemorrhage	Plication sigmoid (1), colorrhaphy (1)	D
G S 34	M	46	C	1 (entrance) in midline of upper abdomen 1 (exit) right "posteriorly"	2 hrs 50 mins	Positive Wassermann	B P 90/50, P 94 Shock	Retropertoneal hematoma perforation of upper pole of right kidney, perforation of anterior upper part of right lobe of liver moderate amount of hemorrhage	Exploration, removal of blood clots and liquid blood	D

P S	M	C	I (entrance) right lower abdomen, 1 (exit) right sacral region	50 mins	B P 88/50, P 120	18 perforations of ileum, perforation of ileal mesentery, large amount of hemorrhage	Ileorrhaphies (18), plication of ileum, suture of peritoneum of mesentery
V C 36	M 35	W	"One wound"	5 hrs 30 mins			
L C 37	M 39	W	"One wound"	1 hr			
E D 38	F 42	C	"One wound"	3 hrs 40 mins	Wound of left arm and forearm, "chest" injury	Perforation of prostate, perforation of rectum, bladder	Cystorrhaphy, suprapubic cystostomy
A L 39	F 25	C	"One wound"	1 hr 10 mins	Positive Wassermann, "chest" injury right side	Evisceration of ileum	Exploration, replacement of eviscerated small bowel
C McC 40	M 41	C	"One wound"	2 hrs 40 mins	Positive Wassermann, left lower chest injury with pneumothorax	Evisceration of jejunum (8 ft), evisceration of transverse colon	Replacement of eviscerated viscera
D P 41	M 30	W	"One wound," right upper abdominal quadrant	1 hr 5 mins	B P 130/80, P 111, R 28	Evisceration of omentum, slight hemorrhage	Exploration, excision of omentum
W S 42	M 19	C	Not recorded	50 mins	B P 180/90	Incised wound of left diaphragm	Lumbar exploration, resection twelfth rib, transpleural repair of diaphragm
J W 43	F 30	C	One wound in left ninth intercostal space in midaxillary line	1 hr 5 mins		Slight hemorrhage	Exploration, internal closure of stab wound
A C 44	M 22	C	One wound above and to right of umbilicus	"Chest" injury to left arm		Incised wound left kidney	Lumbar exploration, partial resection of twelfth rib
H K 45	M 19	W	One wound in right "groin"	"Chest" injury, injury to left arm	B P 96/72, P 96, T 98, R 50	Incised wound of stomach, evisceration of stomach and transverse colon	Gastrorrhaphy, replacement of eviscerated viscera, repair of diaphragm
G McD 46	M 73	W	One wound of left "flank"	Injury to right femoral artery and vein	B P 80/60, P 140	2 perforations and 2 abrasions of stomach, slight amount of hemorrhage	Gastrorrhaphies (2), plication stomach (2)
				"Chest" injury	Severe pain in lower abdomen P 132	Evisceration of omentum	Ligation of femoral vein, suture of femoral artery, excision of omentum
					Abdominal tenderness and rigidity	Evisceration of jejunum (10 ft), one incised wound of jejunum	Plication of serosa of jejunum, jejunorrhaphy, replacement of intestines

The mesentery was injured in many gunshot wound cases in this series. The injuries frequently occurred through avascular areas or near the attachment of the mesentery to the intestine, and in such cases, large vasa recta were not injured, so there was a relatively small amount of intraperitoneal bleeding, and no hematoma formation between the leaves of mesentery. In some cases, however, injuries of the mesentery occurred in the central zone of the mesentery, and were associated with injuries to the mesenteric blood vessels, with resulting extravasation of blood and formation of hematomata between the leaves of mesentery. This second class of mesenteric injuries constitutes a more serious problem because of the difficulty of either locating the ends of the injured vessel or of satisfying one's self that adequate spontaneous hemostasis has occurred and will prevent subsequent bleeding. A third type of mesenteric injury deserves special consideration, *viz.*, mesenteric injuries occurring exactly at the junction of the mesentery with the intestine, and associated with a dissecting hematoma between the leaves of the mesentery. Such injuries require especially close examination in order that it may be determined whether or not there has been partial or complete rupture of the intestinal wall in addition to injury of the mesentery. A fourth type of mesenteric injury, and certainly the most serious of all, is that which occurs near the base of the mesentery, for in this region either injury to, or ligation of, a mesenteric blood vessel interferes with the blood supply to a large segment of intestine. Furthermore, determination of the location, character, and extent of blood vessel injury in this portion of the mesentery is particularly difficult on account of the obscuring hematoma which rapidly develops between the leaves of the mesentery.

Injuries to the gastrocolic, gastrohepatic, or hepatoduodenal omenta may be more or less serious, depending upon the presence or absence of important blood vessel damage or upon the proximity of the injury to the junction of the mesentery with the stomach or intestine. The gastrohepatic mesentery was injured in two cases in this series, both of which lived, and the gastrocolic mesentery was seriously injured in one case, which died.

The great omentum, because of its usual large size, is particularly likely to be injured in penetrating wounds of the abdomen, and injury to omental blood vessels may be responsible for most of the intraperitoneal hemorrhage in some penetrating wounds of the abdomen. Extensive injury to the omentum occurred in two gunshot wound cases. In the stab wound group, evisceration of the omentum occurred in two cases. In several instances, especially in the stab wound cases, the omentum was found to be plugging an opening in the abdominal wall, thus preventing the evisceration of loops of intestine, while in other instances it was found applied over and at least partially sealing intestinal perforations.

Perforations of either hollow or solid viscera are likely to be overlooked in the course of operations for penetrating wounds of the abdomen. Such oversight may result either from the hurried procedure which is necessary in the presence of such injuries, or because of obscuring hematomas. Billings and Walking,⁶⁰ Wilson,¹⁸ and Oberhelman and LeCount⁵⁵ have drawn attention

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to the frequency with which unrepaired perforations are discovered at autopsy. Thorough examination, particularly of the hollow viscera, after all perforations are thought to have been repaired may well precede closure of the peritoneum, if the patient's condition warrants such a recheck. Rectal perforations are



FIG 5—Drawing illustrating the various types of penetrating wounds of the intestines. Multiple wounds, such as those shown at the lower left should be closed separately rather than treated by resection of the segment in which they are located. Wounds at the mesenteric border, such as that shown at the lower right, are particularly likely to be overlooked or imperfectly closed, because of their location and because of the obscuring hematoma, which frequently forms between the leaves of the mesentery.

especially likely to be overlooked in gunshot wound injuries in which the bullet has entered in the gluteal, sacral, or perineal regions. Furthermore, extra-peritoneal hemorrhage is particularly likely to obscure or conceal rectal wounds, even during exploration of the abdomen. Table II shows the various injuries and operative procedures in the present series of cases. Figure 5 illustrates the various types of intestinal injuries found.

Operative Procedures—The operative procedures performed in the present series are shown in Table II. Abdominal exploration and evacuation of liquid blood and blood clots were effected in six cases in which almost no other

procedure was necessary or feasible. Several of the cases in which only exploration and removal of blood were undertaken had inaccessible penetrating wounds of the dome of the liver. In one gunshot wound case, the only injury found at operation was a penetration of a blood vessel in the gastrohepatic omentum, and the sole procedure, in addition to removal of blood and blood clots from the lesser peritoneal cavity, consisted of ligation of the bleeding vessel and closure of the opening in the gastrohepatic omentum. In another case, in which there was a punctate injury of the spleen, with no bleeding at the time of operation, the only procedure was the removal of blood and blood clots. Whenever a perforation was discovered in either the stomach or intestine, examination was made for a possible second penetrating wound in the nearby opposite wall. When a perforation on the anterior wall of the stomach was discovered, the lesser peritoneal sac was opened and the posterior wall of the stomach examined for a possible second penetrating wound. Prey and Foster⁵⁰ found that enlargement of the wound in the anterior wall of the stomach was the simplest and quickest method of revealing, as well as repairing, wounds involving the posterior wall of the stomach.

Method of Closure of Perforations.—Perforations of hollow viscera were usually repaired by means of interrupted or continuous through-and-through sutures which were sometimes supplemented by the introduction of Lembert sutures or Cushing right angle sutures. Purse-string sutures were employed in closing some of the perforations and frequently these were supplemented by a second purse-string suture or by sutures introduced in Lembert or Cushing fashion. Small caliber braided silk on a straight round needle was used for the introduction of the through-and-through, Lembert, or purse-string sutures in the stomach and intestines. Figure 6 illustrates various methods of closing perforations of hollow viscera. When intestinal resection was undertaken, chromic catgut No. 0 or 1, on atraumatic needles, was used for the interlocking through-and-through and loop-on-the-mucosa sutures, and silk was used for seromuscular suturing. On the basis of the results following intestinal resection in comparison with the results, even when many closely located intestinal perforations or lacerations were closed independently, it appears that intestinal resection should be performed only in the presence of an absolute indication. Oberhelman and LeCount⁵³ have also concluded that in only a few instances is resection of viscera or parts of viscera necessary. When resection is resorted to, some type of end-to-end anastomosis other than by means of Murphy button and preferably by one of the "aseptic" or "closed" methods is preferable to side-to-side anastomosis. Less "turn-in" or spur formation can usually be better assured by employing the Fuiniss⁶¹ method.

The performance of enterostomy, in anticipation of ileus, is unwarranted. The results obtained by means of enterostomy are unsatisfactory and there is a danger of producing intestinal obstruction either through the production of stenosis or angulation at the site of enterostomy, or through the development of a volvulus about the loop of intestine which is fixed to the abdominal wall.

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Furthermore, the objectionable and dangerous effects, including excessive loss of fluids, which are likely to follow jejunostomy and sometimes even ileostomy, suggest that enterostomy should seldom, if ever, be performed in cases of penetrating wounds of the abdomen. This attitude in respect to the performance of enterostomy has been partly due to the development of safer and more efficient methods for the prevention of distention of the small intestine, such as the maintenance of continuous suction through an indwelling

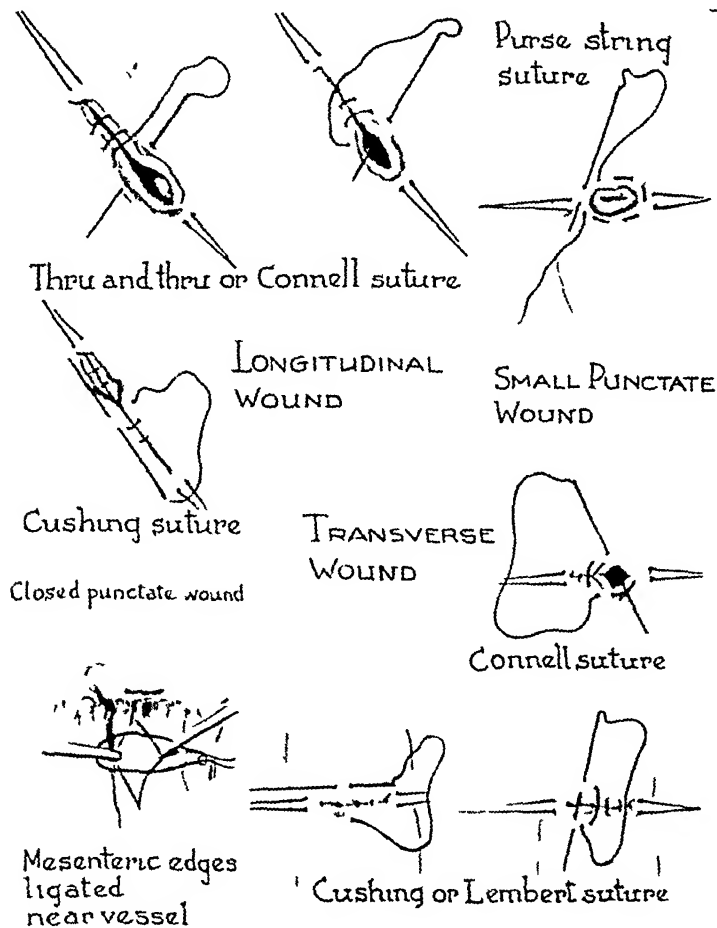


FIG 6—Drawing showing various methods of repairing perforations of hollow viscera. The figure at the lower left indicates the method of repairing defects in the mesentery by ligation rather than by suture closure of the defect, which latter procedure entails the risk of perforating mesenteric vessels which are obscured by a hematoma between the leaves of the mesentery.

gastroduodenal catheter, or even a Miller-Abbott tube, and the hypodermic administration of large doses of morphine.

Hepatorrhaphy was performed in two gunshot wound cases in which extensive stellate or lacerated wounds were present. Heavy chromic catgut was used to approximate the liver surfaces. In addition to gauze packs which were used in several instances to control bleeding from the liver, hot compresses were applied directly to the exposed liver surfaces during the operation, and in still other instances, strips of rectus muscle were removed, macerated, and applied to the bleeding surfaces.

The mesentery of the small intestine was repaired in nine instances in the

gunshot wound group Although the amount of bleeding from the mesentery was slight to moderate in most instances, in two cases very active bleeding from blood vessels in the mesentery was observed at the time of operation In none of the stab wound cases was there occasion to repair the mesentery On account of the danger of strangulation or puncture of vessels in the mesentery or omentum, which is likely to occur when these structures are sutured, mesenteric or omental defects, both small and large, were usually closed by grasping the divided mesentery or omentum at opposite points with forceps and tying together the portions of mesentery or omentum within the grasp of forceps as shown in the lower left illustration in Figure 6

When evisceration of the omentum had occurred, the eviscerated omentum and the surrounding abdominal wall was cleansed, traction on the omentum was made until previously nonprotruding omentum was withdrawn, and the eviscerated omentum was then resected The ligated stump of omentum was replaced just before the abdomen was opened for exploration Aside from the importance of arresting hemorrhage, accurate closure of defects in the mesentery and omentum was effected in order to prevent the occurrence of internal herniae

With the exception of one stab wound case, all kidney injuries in this series were associated with other visceral injuries In no case was nephrectomy performed, because what is considered to be the only absolute indication for nephrectomy in penetrating wounds of the abdomen, *i e*, extensive injury in the region of the renal hilum, was not recognized in any instance Gauze packs or cigarette drains were introduced through the injury in the kidney and allowed to exit through the lumbar bullet or stab wounds or through a surgically made stab wound in the lumbar region Wounds in the peritoneum overlying the kidney were sutured to prevent hemorrhage or leakage of urine into the peritoneal cavity The extensive perirenal hemorrhage usually present made exact location of the kidney injuries difficult Since extravasation of urine in the retroperitoneal space is likely to result from obstruction to the outflow of urine caused by blood clots in the pelvis of the kidney or in the ureter, a large indwelling ureteral catheter was introduced up to the pelvis of the kidney in several of the gunshot wound cases The ureteral catheters were aspirated or even gently irrigated at frequent intervals following operation Also, ureteral catheterization was performed preoperatively in three cases in the gunshot wound group in which injury to the ureter or bladder was suspected either because of the course of the bullet or because of preoperative hematuria

Closure of wounds of the urinary bladder, or plication of the bladder wall in instances of incomplete penetration of the bladder, was performed in three instances in the gunshot wound group

Transpleural repair of an incised wound of the diaphragm was performed in one instance in the stab wound group in which the knife causing the incised wound of the diaphragm entered the thorax and traversed the pleural cavity

The injury in this instance occurred on the left side and, before closure of the diaphragmatic wound was effected, the chest wall wound was enlarged and the cardiac portion of the stomach was drawn through the opening in the diaphragm and inspected. A punctate wound of the right diaphragm was found in one of the gunshot wound cases in which the dome of the liver was penetrated. Because of the practical impossibility of suturing such wounds transperitoneally, and because of the likelihood of adequate spontaneous shutting off of the communication between the chest and abdominal cavities by the close application of the liver to the diaphragm, no attempt was made to repair this injury. Transabdominal repair of the diaphragm was performed in one case in the stab wound group in which there was associated evisceration of intestine and stomach.

Lumbar exploration of the abdomen following resection of the twelfth rib was performed in two cases of the stab wound group in which the patient had received stab wounds in the lumbar region. A rubber tissue flap was placed over a "sucking" stab wound of the chest in one case, in order to prevent the development of tension pneumothorax. Within the limits permitted by the patient's general condition, a careful and complete débridement of associated injuries to such structures as the breast, the hand, and other extra-abdominal structures was done. Ligation of the femoral vein, and arteriorrhaphy of the femoral artery, was done in one of the stab wound cases.

Exposure of and ligation of actively bleeding veins in the space of Retzius was necessary in one case in the gunshot wound group in which an extensive perivesical hematoma was present. Exploration of and ligation of veins in the broad ligament was also required in one instance in which a dissecting hematoma extended into the lateral perivesical space. Extruded hollow viscera were cleansed with normal saline solution and perforations in them were sutured before the viscera were replaced in the abdomen, and before finally placing drapes in preparation for celiotomy.

Irrigation or lavage of the peritoneal cavity was employed in only one instance—a gunshot wound case in which considerable spillage of intestinal contents had occurred. Although this patient lived, it is believed that peritoneal lavage should rarely be done. Because of the time required to even partially remove foreign material by this means, and because of the likelihood of causing disseminated contamination, peritoneal lavage is not only likely to be valueless, but it is probably harmful. On the other hand, postoperative morbidity and mortality may be considerably reduced by picking out, sucking out, or sponging out any liquid blood, blood clots, detached particles of viscera, intestinal contents, wadding, bullets, or particles of clothing found within the peritoneal cavity.

Prolonged search for bullets was not made at the time of operation. Unless the patient's condition was very good, only those bullets which were incidentally found were removed at the time of the principal operation. In several instances, bullets were found lying free in the abdominal cavity, in one

instance a bullet was found lodged in the cecal wall, while in still another case a bullet was found lodged in the wall of the sigmoid

Bullet wounds of entrance and exit were usually debrided at the time of operation, but even the slight prolongation of anesthesia necessary to permit such debridement was sometimes considered unwarranted. In some instances drains or packs were conducted through enlarged wounds of entrance or exit.

One or two cigarette drains were introduced in nine of the gunshot wound cases which lived. In five of these cases, the drain was introduced through a stab wound made at the time of operation, and located in most instances lateral to the principal incision, although in two instances the drain was placed at one end of the celiotomy incision. In one instance, the drain passed through an enlarged bullet wound of entrance, while in still another instance the drain was passed through an enlarged wound of exit. One or two cigarette drains were also used in six of the gunshot wound cases which died, in two cases the drain was introduced through a surgically created stab wound, in two instances through the principal operative incision, and in two instances through an enlarged bullet entrance wound. A single cigarette drain was used in one of the stab wound cases which lived, the drain being introduced through a stab wound made at the time of operation. In two stab wound cases which died, the drains were brought out through the original stab wounds. Because of the impossibility of draining the peritoneal cavity and because of the danger of intestinal obstruction resulting from the introduction of drains into the peritoneal cavity, the intraperitoneal introduction of drains at the time of operation for penetrating wounds of the abdomen is now considered futile.

Closure of the abdominal operative incision was, in most instances, accomplished by means of continuous No. 2 chromic catgut sutures for approximation of the peritoneum and transversalis fascia, interrupted No. 2 chromic catgut for approximation of skin and subcutaneous fat, and for retention sutures. It is felt, at present, that better wound healing can be obtained by using interrupted sutures of braided or twisted silk throughout the layered closure of such wounds. Even though the operative incisions in penetrating wounds of the abdomen are usually contaminated, the significant findings of Shambaugh and Dunphy,⁶² concerning various suture materials in relation to the healing of contaminated or infected wounds, indicate that less serious wound infections and fewer wound ruptures are likely to occur when silk ligature and suture material is employed. Cotton thread may also be employed in preference to catgut for ligatures and sutures.

Rubber tissue drains, placed between or beneath the rectus muscle and either beneath or above the anterior rectus sheath, were usually introduced and allowed to remain in place for from 48 to 96 hours before being completely removed. Drainage of the operative wound in cases of penetrating wounds of the abdomen is particularly advisable, as a safeguard against the possible fatal intraperitoneal rupture of an abdominal wall abscess.

Duration of Operation—The duration of operation in cases in which this factor was recorded averaged 60 minutes in the survival group, and 82 min-

utes in the fatal group, as shown in Figure 7. That a direct relationship exists between the duration of operation and the mortality in penetrating wounds of the abdomen is certainly to be expected, and Oberhelman and LeCount⁵⁵ have for this reason strongly advised the avoidance, if at all possible, of time-consuming procedures such as intestinal resection.

Postoperative Course, Including Postoperative Complications—Nausea or vomiting occurred in only 11 cases in the gunshot wound group. In the stab wound group, nausea or vomiting occurred in three cases. Postoperative pain of considerable degree was present in only nine cases in the gunshot wound group and in three cases in the stab wound group. Postoperative distention was present to a considerable degree in 11 cases of the gunshot wound group and a notable degree of ileus occurred in three cases in the stab wound group. The relatively low incidence of the above distressing postoperative symptoms was no doubt, in large measure, due to the employment of indwelling gastric or duodenal catheters, and to the administration of adequate doses of sedatives as well as to the routine application of heat to the abdomen.

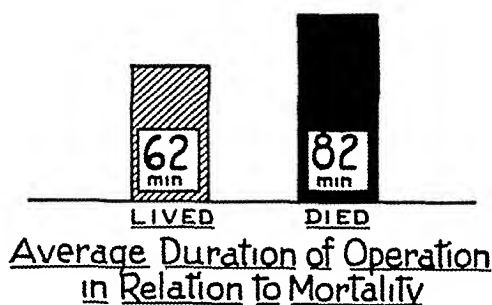


FIG 7—Graphic representation showing the influence of the duration of operation upon the mortality in the present series of cases.

Peritonitis was recorded as occurring in only four cases in the combined group, with one survival and three deaths, the only instance of survival occurring in a gunshot wound case. The remaining two gunshot wound cases and the one stab wound case died. There were evidently many more instances of peritonitis, both in the group which lived and the group which died, than is indicated by these figures. In fact, peritonitis must have played an important part in practically all of the fatalities, with the exception of those cases in which death was due to shock and hemorrhage. Careful observations for postoperative residual abscess such as subphrenic and culdesac abscesses, and the proper drainage of such purulent accumulations constitute an important part of the postoperative observation and treatment of penetrating wounds of the abdomen.

An intestinal fistula persisted in one gunshot wound case and necessitated a subsequent operation for its closure. The management of intestinal fistulae has been considered in an excellent review by Hartzell⁶³. Although no patient in this series developed a pancreatic or duodenal fistula, it is noteworthy that bronzing powders may be applied to advantage for the protection of the skin and for the prevention of the digestion of the abdominal wall which usually accompanies pancreatic, duodenal, and high jejunal fistulae. Also, the employment of some sort of suction apparatus to continuously remove outpouring secretions affords symptomatic relief and hastens the closure of such fistulae.

Pulmonary atelectasis, pneumonia, and pulmonary embolism are particularly likely to occur in patients who have had penetrating wounds of the abdomen. Hemorrhage, shock, and relatively prolonged anesthesia without

benefit of adequate preanesthetic preparation, as well as postoperative peritonitis and ileus, frequently coexist or occur in sequence in patients with gunshot wounds of the abdomen. Transfusion, ample hydration, early mobilization, the application of heat, avoidance of tightly applied dressings, and the encouragement of forced, deep breathing, as well as postoperative hyperventilation by means of carbon dioxide-oxygen inhalations immediately after operation and during the subsequent postoperative period, as has been variously suggested by Snyder,⁶⁴ Cutler and Hunt,⁶⁵ Sante,⁶⁶ and Henderson,⁶⁷ are all methods which may be advantageously and effectively employed to minimize pulmonary complications. The postoperative aspiration of mucus from the respiratory tract by means of a catheter introduced immediately following operation or sometimes during the later postoperative period may also at times serve to prevent or relieve postoperative pulmonary complications. Aspiration of mucus with the aid of a bronchoscope may occasionally be necessary, but the proper application of other simpler methods makes bronchoscopic drainage rarely necessary.

Considerable infection of the operative wound occurred in eight gunshot wound cases, seven of which lived. There were no serious operative wound infections among the stab wound cases. Postoperative wound rupture or evisceration occurred in one gunshot wound case, necessitating secondary closure of the wound. This patient died. Separation of wound edges without evisceration occurred in two gunshot wound cases, both of which lived. The use of interrupted silk sutures instead of catgut for closing the operative incision might have averted the wound ruptures.

Jaundice, due to absorption of large amounts of blood pigment from the retroperitoneal space or peritoneal cavity, occurred postoperatively in one gunshot wound case. Other miscellaneous postoperative complications included a second degree burn of the thigh, produced by a hot water bottle. One of the stab wound cases which survived developed bilateral vasitis, epididymitis and a scrotal abscess. Sudden unexplained collapse, evidently the result of embolism, was followed by death in one stab wound case.

Postoperative Treatment—Postoperative treatment consisted in many instances of continuing measures which had been instituted either preoperatively or during the operation. In addition to external heat applied by means of hot water bags, a heat tent was placed over the abdomen in practically all cases.

At one time or another during the postoperative period of most of the cases of this series, either the head or the foot of the bed was elevated six to twelve inches. When patients were in shock, the foot of the bed was elevated, whereas when spillage into the peritoneal cavity of material which might lead to the formation of a subphrenic or residual abscess had occurred, the head of the bed was elevated. Relatively large amounts of morphine were administered for the relief of pain, to secure rest, and for the tone stimulating effect of this drug on the intestinal musculature. It is remarkable that the erroneous belief that morphine causes ileus has persisted, following the demonstration by Gruber⁶⁸ of the tone and peristaltic stimulating influence of this drug. The

desirable influence of morphine in the presence of ileus has been demonstrated by Ochsner, Gage, and Cutting⁶⁹ Intravenous hypertonic, lactated Ringer's solution, in a 20 times normal concentration and in amounts varying from 6 to 12 cc, may be employed to advantage to increase intestinal tone and peristaltic activity in the presence of ileus

An indwelling gastroduodenal catheter, introduced through the nose, was used postoperatively in a total of 25 cases in the combined gunshot and stab wound groups Fifteen of these cases lived and ten died Postoperative gastric lavage with warm saline or sodium bicarbonate solution was performed in a total of 13 cases in the combined group, nine of which lived and four of which died Although careful postoperative gastric lavage may be employed to advantage when the stomach has been penetrated and contains liquid or clotted blood, the performance of gastric lavage is usually not necessary or advisable Immediate postoperative introduction of an indwelling catheter attached to a suction apparatus almost always obviates the need for gastric lavage The indwelling catheter should be of large size, with many perforations, and it should be left in place until a normal pyloric balance has been established

Enemata and colonic flushes were given to 19 of the gunshot wound cases Seven of the stab wound cases received enemata and flushes Since the abdominal distention which occurs postoperatively in penetrating wounds of the abdomen is principally due to ileus of the small intestine, enemata and flushes are likely to be ineffectual Exhaustion or increased discomfort of the patient as well as an increase of the degree of ileus and distention is likely to follow repeated large flushes During convalescence, and after recovery from adynamic ileus has occurred, small purgative enemata may sometimes be safely and advantageously administered A colon tube was inserted in several instances for the purpose of facilitating the elimination of accumulations of gas in the large intestine

Surgical pituitrin was administered to seven of the gunshot cases, three of which lived and four of which died The clinical and experimental demonstration by Ochsner, Gage, and Cutting⁶⁹ that pituitary extract usually fails to produce an increase, and may even cause a decrease, of intestinal tone and peristaltic activity, indicates that this drug should seldom, if ever, be used in attempts to relieve ileus Of the drugs which are commonly employed for the purpose of stimulating peristalsis, eserine or prostigmine methylsulphate appears to be most effective The observations of Fine and Hermanson,⁷⁰ indicating the favorable influence of a high concentration of oxygen in the lung alveoli in causing reduction of intractable distention, can be advantageously applied in the postoperative management of ileus associated with penetrating wounds of the abdomen Oxygen therapy for the relief of ileus may be administered by means of a catheter introduced through the nose, by means of an oxygen tent, or by employing the method developed by Boothby,⁷¹ Lovelace⁷² and Bulbulian⁷³

Secondary or delayed enterostomy was not undertaken in any case in either

group Since the development of superior methods of treating ileus, this usually futile procedure has little place in the postoperative management of penetrating wounds of the abdomen The Miller-Abbott tube may prove of value in selected cases of postoperative intestinal obstructions, particularly of the water-hose kink variety

Postoperative transfusion of either whole or citrated blood was administered in a total of 13 cases, six of which lived and seven of which died The average amount of blood given was 673 cc The six gunshot wound cases which lived received an average of 600 cc, and the six gunshot wound cases which died received an average of 820 cc In all of the gunshot wound cases, the citrate method was used The only stab wound case which received a transfusion was given 300 cc of untreated blood Although more frequent and larger postoperative transfusions of whole blood might have averted several of the fatalities in this series, the several factors already referred to in the discussion of preoperative transfusion frequently made adequate transfusion impossible

The methods now available for quick determination of plasma protein levels, including the falling-drop method⁴⁸ and the Bing-bead method,⁴⁹ now make it relatively easy to ascertain that this blood constituent is at the level necessary for proper wound healing and other reparative and regenerative processes A lowered plasma protein level is likely to result from the necessary restriction of adequate amounts of protein derived from oral feeding Plasma protein depletion is a factor in defective wound healing, it may also lead to the complete occlusion of the intestinal lumen at a site which has been narrowed during the repair of perforations, with resulting complete obstruction such as has been shown to sometimes occur at the ostomy of gastro-enterostomies Leakage along suture lines and at the sites of repair of intestinal perforations has no doubt in some cases been due to inadequate fibrin formation Peritonitis, resulting from such leakage, has surely been responsible for some of the deaths following penetrating wounds of the abdomen, and might have been prevented by the administration of adequate transfusions of whole blood, or the administration of lyophilized serum

Infusions, which in many instances were administered as a continuous intravenous drip, were given to ten cases, the average amount being 700 cc Eight of these patients died, five of the deaths occurring in the gunshot wound group, which received an average of 1,000 cc of 5 per cent glucose and normal saline The one gunshot wound case which lived received 2,500 cc of a mixture of 10 per cent glucose and normal saline Three of the four stab wound cases which received infusions died The fatal stab wound cases which were given infusions received an average of 2,500 cc of 10 per cent glucose In addition to the infusions, an intravenous drip of 10 per cent glucose and saline was administered to three gunshot wound cases, all of which died after receiving an average of 4,000 cc

Hypodermoclyses were usually administered in the subcutaneous tissues of the medial aspects of the thighs rather than in the subcutaneous tissues of the

chest These clyses consisted of a mixture of equal parts of 10 per cent glucose and normal saline and were administered to practically all cases in both groups during the postoperative period For the combined groups, the average amount given was 3,451 cc, those which lived receiving an average of 3,904 cc, while those which died received an average of 2,615 cc The gunshot wound cases which lived received an average of 4,060 cc, while those which died received an average of 2,927 cc The stab wound cases which lived received an average of 3,125 cc, while those which died received an average of 1,000 cc

Insulin, given for the purpose of buffering glucose in infusions, was administered to four patients in an average dose of 46 units, for the combined group In the combined group, those patients who were given insulin and lived, received an average of 55 units, while those who received insulin and died were given an average of 37 units Two gunshot wound patients who received insulin and lived were given an average total dose of 32.5 units There is no record of any fatal gunshot case having received insulin Of the two stab wound cases, one of which lived and one of which died, each received a total of 60 units The administration of insulin along with glucose of more than 5 per cent concentration is particularly advisable in view of the demonstration by Ochsner, *et al*,⁵⁷ of the peristaltic inhibiting effect exerted by glucose of more than 5 per cent concentration

Adhesive plaster strapping of the chest was done on one gunshot wound case, who had an associated chest injury Aspiration of the pleural cavity was necessary in another case in which there was an associated hemothorax

In a few cases in which postoperative bleeding occurred, various "hemostatic" drugs were employed "Antivenin" was given intramuscularly in the case of one gunshot wound case which died "ceanothyn" was administered orally in repeated doses of one or more ounces to two gunshot wound cases, one of which lived and one of which died, "coagulen," in doses varying from 3 to 25 cc, intramuscularly, was given to four gunshot wound cases, two of which lived and two of which died, parathyroid hormone, in doses varying from 5 to 30 units, was administered to four gunshot wound cases, two of which lived and two of which died, calcium chloride was given intravenously in doses of from 15 to 45 gr to three gunshot wound cases, two of which lived and one of which died Calcium lactate was administered to one gunshot wound case which lived In several instances, two or more hemostatic agents were administered to the same patient These drugs were either given singly or in such varying combinations that, especially in consideration of the small number of cases in which they were used, no conclusions could be drawn concerning the efficacy of any of them Epinephrine hydrochloride was administered hypodermically or intravenously to 14 of the combined gunshot and stab wound cases The average total amount given to four cases in the combined group which lived was six minims, while the average amount received by ten cases which died was 15.6 minims Unless a large dose seemed absolutely necessary, the epinephrine was administered hypodermically in

repeated doses of two or three minims, every one or two hours, or even more frequently. In still other cases, the epinephrine was added to a saline or glucose infusion. Despite the undesirable cardiovascular effects of epinephrine, its administration in some cases seemed to be imperative. Furthermore, although epinephrine causes depression of intestinal tone and inhibits peristaltic activity, restoration or maintenance of the blood pressure may necessitate the use of this drug. Because of the damage of the suprarenal glands which may be associated with ileus due to peritonitis, adrenal cortical extract might be used to advantage in penetrating wounds of the abdomen associated with ileus. The preparation of desoxycorticosterone acetate, as employed by Thoin, *et al*,⁷⁴ in Addison's disease, might be employed for this purpose.

Caffeine sodium benzoate was administered to 14 of the patients in the combined gunshot and stab wound groups. Combining the gunshot and stab groups, the amount of caffeine sodium benzoate administered was 7.5 gr. in one case which lived, while in 13 cases which died the average total dose was 16.5 gr.

Digitalis preparations were administered subcutaneously, intramuscularly, or intravenously to a total of 11 cases. Although all but two of the patients who received digitalis died, every one of these patients was in extremely poor condition. The absence of strikingly beneficial effects of digitalis might be expected in such cases as those in this series, who had a simple sinus tachycardia without disturbance of the normal conduction mechanism. Under such circumstances, digitalis is not effective in improving cardiac efficiency and may even exert only a toxic effect.

The important rôle which the vitamins play in wound healing, resistance to infection, and in maintaining liver function makes the postoperative administration of ample amounts of concentrated vitamins by parenteral or oral routes, as suggested by Vorhaus,⁷⁵ obviously important in the instance of patients who are recuperating after penetrating wounds of the abdomen.

Urinary antiseptics, *i e*, "selenium," "pyridium," or methenamine and sodium acid phosphate, were administered to a total of five cases in the combined group, all of which lived. These drugs were employed either for the treatment of established urinary tract infections or for prophylaxis when suprapubic cystotomy had been performed, or when indwelling ureteral catheters were installed. Except during the time when bladder irrigations were being performed, a small catheter connected to a suction apparatus was kept inserted in the suprapubic tube with the tip of the small catheter reaching to or beyond the tip of the surrounding catheter, in order to keep the bladder empty.

Antiluetic treatment was administered postoperatively to six patients in the combined group, three of which lived and three of which died. Mercurialism, manifested by stomatitis and salivation, was observed in one of the gunshot cases receiving "mixed" treatment postoperatively. This condition improved rather rapidly following the discontinuance of the mercury preparation, and the patient lived.

Perfringens serum was given postoperatively to one gunshot wound case which lived. Polyvalent antianaerobic serum might have been advantageously administered to some cases. The coli-bacteriagen, advocated by Steinberg⁷⁶ for the prevention of peritonitis, and such chemotherapeutic agents as sulfanilamide and sulfapyridine were not available during the period in which the cases in this series were observed, but may possibly be of value in cases of peritonitis resulting from penetrating wounds of the abdomen.

Mortality—The mortality in the present series of cases, as shown in Figure 8, although comparing favorably with other comparable series, is discouragingly high. Had the methods which are at present applicable in the management of penetrating wounds of the abdomen been available, and had all these improved methods been consistently applied in the treatment of the cases included in this report, it is reasonable to expect that the mortality might have been considerably lower. Although, because of the very nature of such injuries, the mortality in penetrating wounds of the abdomen will inevitably remain relatively high, the constant improvement in methods of treating shock, hemorrhage, ileus, and peritonitis is encouraging.

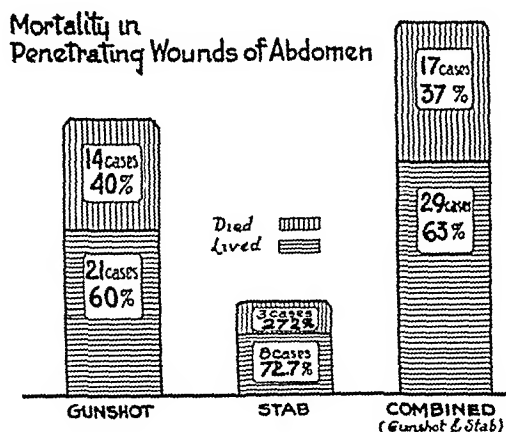


FIG 8—Graphic representation showing the mortality in the present series of penetrating wounds of the abdomen.

SUMMARY AND CONCLUSIONS

(1) The present report is based on 46 personally managed cases of penetrating wounds of the abdomen, 35 of which were gunshot wounds, and 11 of which were stab wounds.

(2) Facilities for quick transportation, arrangements to shorten the preoperative duration of the injuries, and provisions for promptly combating shock and hemorrhage are important in the management of penetrating wounds of the abdomen.

(3) The symptoms associated with penetrating wounds of the abdomen are frequently indefinite. Pain is frequently slight or absent. Penetrating wounds of the abdomen which occur via the gluteal, sacral, or perineal regions are particularly likely to be overlooked because of the frequent absence of early symptoms.

(4) Physical findings in penetrating wounds of the abdomen may be misleading. Tenderness and rigidity are not constantly present.

(5) Examination of the urine for gross or microscopic blood should be made in order to reveal or confirm the presence of injuries of the urinary tract.

(6) Red blood cell counts and hemoglobin determinations may be misleading or late indicators of hemorrhage.

(7) Roentgenologic examination is often of value in the preoperative determination of probable injuries

(8) The recognition of associated injuries, particularly those of the chest, is important in the management of penetrating wounds of the abdomen

(9) Study of wounds of entrance and exit may indicate whether or not penetration of the abdomen has occurred. When there is uncertainty concerning penetration of the abdomen, exploratory celiotomy usually should be performed. Even when the wounds have been produced by small-sized shot, abdominal exploration should be performed.

(10) A short interval between the time of injury and the time of operation usually favorably influences the outcome, but operations should be delayed until patients have at least considerably recovered from shock. In upper abdominal penetrating wounds, operation may be necessary and is relatively safe during a longer period than in wounds which involve the lower portions of the abdomen.

(11) Prolonged shock produces irreversible deleterious effects, therefore, attempts should be made to rapidly combat shock and hemorrhage.

(12) The extent of hemorrhage largely determines the outcome in penetrating wounds of the abdomen. In the presence of considerable hemorrhage, transfusions during and shortly after operation and totaling as much as 3,000 cc of blood may be necessary. Transfusion registries and blood banks are important in making available adequate supplies of blood. Transfusions of blood should, whenever possible, displace the administration of saline or glucose infusions or stimulant drugs.

(13) Spinal anesthesia may be employed to advantage in selected cases.

(14) The ricochet of bullets, as well as variations in the relative position of parts of the patient's body at the time of injury, as compared with the position of the same parts on the operating table, accounts for apparently bizarre courses of bullets. Unexpected and unpredictable visceral injuries due to the position of the patient, or the phase of respiration at the time of injury, were frequently observed. The specific injuries observed in the present series of cases are listed in Table II.

(15) The total number of perforations of either hollow or solid viscera was only slightly less in the group which lived than in the group which died.

(16) Whenever perforation of one wall of a hollow viscus is detected the opposite wall of the viscus should be examined for possible injury.

(17) The mortality rate was unusually low in the group of cases with large intestine injury, probably because of the relatively small amount of spillage which accompanies such injuries.

(18) Extraperitoneal hemorrhage or hemorrhage between the leaves of the mesentery is likely to obscure important injuries.

(19) Injuries of the gallbladder, bile ducts, pancreas and kidneys are extremely serious. Perforations of the spleen usually require splenectomy. Hemorrhage from lacerations of the liver may sometimes be satisfactorily

sutured, but in other instances hemorrhage from lacerated surfaces of the liver can best be controlled by means of packs

(20) Unrepaired perforations are frequently discovered at autopsy, therefore, reexamination after all perforations are thought to have been repaired is advisable if the patient's condition warrants such a procedure

(21) Because of the important relationship between hemorrhage and mortality, attention during operation should be directed first to the arrest of bleeding

(22) Time-consuming procedures, such as intestinal resection, should be avoided whenever possible

(23) Mechanical anastomosis devices should rarely if ever be used

(24) Enterostomy is usually ineffectual, and has been displaced by better methods of preventing or combating ileus

(25) Drains introduced into the peritoneal cavity are usually unnecessary and undesirable, but drainage of the abdominal wall should be instituted when hollow viscera have been perforated

(26) Silk or cotton sutures and ligatures are superior to catgut for the repair of hollow viscera and for the closure of the abdominal wall

(27) Irrigation or lavage of the peritoneal cavity is usually futile, but it is desirable to suck out or pick out from the peritoneal cavity liquid blood, blood clots, detached particles of viscera, intestinal contents, and foreign bodies

(28) Postoperative attention should include measures to combat any still-existing shock or effects of hemorrhage

(29) The application of heat to the abdomen, the administration of large doses of morphine, the establishment of gastroduodenal suction drainage, the avoidance of enemata and flushes, and the infusion of glucose and lactated Ringer's solution are effective measures in preventing or reducing the severity of ileus and peritonitis. The Miller-Abbott tube as well as oxygen therapy may be employed to advantage in selected cases

(30) Biologic preparations, such as coli-bactiagen, and chemotherapeutic agents such as sulfanilamide and sulfapyridine may prove of value in reducing the mortality from peritonitis resulting from penetrating wounds of the abdomen. Desoxycorticosterone acetate, or other preparations containing the adrenal cortex hormone, may benefit those cases in which peritonitis is anticipated or already exists

(31) Vitamins should be administered parenterally or orally to favor wound healing and to compensate for the general vitamin deficiency which is likely to develop during the postoperative period

(32) Lyophilized serum or whole blood transfusions are sometimes necessary to maintain plasma protein at a normal level during the postoperative period

(33) Atelectasis and pneumonia frequently complicate penetrating wounds of the abdomen, therefore, measures should be taken to prevent or promptly treat these pulmonary complications

(34) The mortality of penetrating wounds of the abdomen is, and will,

surely continue to be, disappointingly high. In the present series, the mortality in the stab wound cases was 27.2 per cent, the mortality in the gunshot wound cases was 40 per cent, and the combined mortality was 37 per cent. However, recent advances in the treatment of shock, hemorrhage, ileus and peritonitis, all of which are so important in the management of penetrating wounds of the abdomen, are encouraging.

BIBLIOGRAPHY

- ¹ Miles, A. B. Report of a Case of Gunshot Wound of the Abdomen. *Southern Surg and Gynec Trans*, 3, 436, 1890.
- ² Parker, W. E. Bullet Wounds of the Abdomen. *Southern Surg and Gynec Trans*, 9, 272, 1896.
- ³ McRae, Floyd W. Penetrating Wounds of the Abdomen. Report of Cases. *Southern Surg and Gynec Trans*, 11, 22, 1898.
- ⁴ Crofford, T. J. Peritonitis, with Perforation of Small Intestine. Gunshot Wound of the Abdomen, with Thirteen Perforations. *Southern Surg and Gynec Trans*, 12, 200, 1899.
- ⁵ Grant, H. H. Treatment of Gunshot Wounds of the Abdomen. Some New Statistics. *Southern Surg and Gynec Trans*, 12, 37, 1899.
- ⁶ Wysoi, John C. Report of a Case of Gunshot Wound of the Abdomen. *Southern Surg and Gynec Trans*, 14, 178, 1901.
- ⁷ Fenner, E. D. Penetrating Wounds of the Abdomen. Histories of Six Laparotomies and Statistical Tables of 152 Cases Operated Upon at the Charity Hospital, New Orleans, La. *Southern Surg and Gynec Trans*, 14, 180, 1901.
- ⁸ Neff, Wallace. Gunshot Wounds of the Abdomen. *Southern Surg and Gynec Trans*, 14, 363, 1901.
- ⁹ Caldwell, C. E. Penetrating Wounds of the Abdomen. Report of Cases. *Southern Surg and Gynec Trans*, 18, 398, 1905.
- ¹⁰ Guerry, LeGrand. Report of Eight Consecutive Cases of Gunshot Wound of the Abdomen, with One Death. *Southern Surg and Gynec Trans*, 20, 348, 1907.
- ¹¹ McRae, Floyd W. Penetrating Wounds of the Abdomen. *Southern Surg and Gynec Trans*, 21, 236, 1908.
- ¹² Mason, J. M. The Influence of Hemorrhage on the Mortality in Gunshot Wounds and Other Injuries of the Abdomen. An Analysis of 69 Cases. *Trans Southern Surg Assn*, 35, 36, 1922.
- ¹³ Mason, J. M. The Influence of Hemorrhage on the Mortality in Gunshot Wounds and Other Injuries of the Abdomen. A Supplementary Report, with Analyses of 127 Cases. *Trans Southern Surg Assn*, 36, 499, 1923.
- ¹⁴ Bunch, George H. Shotgun Wounds of the Abdomen. *Trans Southern Surg Assn*, 41, 38, 1928.
- ¹⁵ Willis, Byrd Charles. Penetrating Wounds of the Abdomen Received from Pistol, Rifle, and Shotgun Missiles. Report of 63 Cases. *Trans Southern Surg Assn*, 44, 114, 1931.
- ¹⁶ Willis, Byrd Charles. Shotgun Wounds of the Abdomen. *Trans Southern Surg Assn*, 47, 215, 1934.
- ¹⁷ Willis, Byrd Charles. Shotgun Wounds of the Abdomen. Report of Experimental Work. *Am Jour Surg*, 28, 407, 1935.
- ¹⁸ Wilson, Frank C. Gunshot Wounds of the Abdomen. *Southern Med Jour*, 27, 805, 1934.
- ¹⁹ Storck, Ambrose H. Gunshot Wounds of the Abdomen, I. A Consideration of Their General Management. Report of Thirty-Five Personal Cases. *Southern Surg*, 8, 148, 1939.
- ²⁰ Matas, Rudolph. Personal communications.

- ²¹ Loria, Frank L Visceral Injuries in Gunshot Wounds of the Abdomen New Orleans Med and Surg Jour , 80, 283, 1927-1928
- ²² Loria, Frank L Prognostic Factors in Abdominal Gunshot Wounds New Orleans Med and Surg Jour , 83, 393, 1930-1931
- ²³ Loria, Frank L The Influence of Hemorrhage in Abdominal Gunshot Injuries ANNALS OF SURGERY, 96, 169, 1932
- ²⁴ Miller, Martin O Gunshot Wounds of the Abdomen The Immediate End-results in 46 Cases, New Orleans Med and Surg Jour , 80, 279, 1927-1928
- ²⁵ Bastos, M Sobre el pronostico en los heridos de guerra del vientre Rev san de guerra, 2, 1, 1938
- ²⁶ Butler, E Injuries of Chest and Abdomen Surg , Gynec and Obstet , 66, 448, 1938
- ²⁷ Capruciu, G Case of Bayonet Wound with Multiple Intestinal Perforations and Acute Peritonitis Rev san mil Bucuresti, 36, 417, 1937
- ²⁸ Cubbins, W R, Callahan, J J, and Scuderi, C S Thoracic Wall Injuries Complicated by Lesions to Thoracic and Abdominal Viscera Emergency Treatment Nebraska Med Jour , 23, 11, 1938
- ²⁹ Culligan, J M Perforating Wounds Minnesota Med , 22, 397, 1939
- ³⁰ Gomez Durán, M Anatomia topográfica de las heridas penetrantes de vientre Semana méd españ , 1, 143, 1938
- ³¹ Gilorteanu, I, and Ionesco, V Plaie pénétrante bipolaire de l'abdomen par baïonnette, guérison sans intervention Rev de Chir , Bucuresti, 40, 129, 1937
- ³² Gilorteanu, I, and Gostescu, P Sequels of War Wounds of Abdomen Rev sans mil , Bucuresti, 36, 135, 1937
- ³³ Guillaume-Louis, P Le diagnostic des "gros genoux" Hôpital, 26, 286, 1938
- ³⁴ Jones, E M Abdominal Injuries Minnesota Med , 21, 828, 1938
- ³⁵ Kreuschner, P H Injuries to Right Upper Abdominal Quadrant Illinois Med Jour , 74, 419, 1938
- ³⁶ Lanzillo, F Ferita d'arma da fuoco dell' ipocondrio sinistro con scoppio del rene sinistro e della milza e ferita passante dello stomaco e del fegato Riforma med , 54, 1281, 1938
- ³⁷ Maass, J Algunas modificaciones en la exploracion y terapeutics de urgencia en las heridas del abdomen Cir y cirujanos, 6, 317, 1938
- ³⁸ Meyer, K, and Shapiro, P F Treatment of Abdominal Injuries Collective Review Internat Abstr Surg , 66, 245, 1938 (in Surg , Gynec and Obstet , March, 1938)
- ³⁹ Mitchner, P H, and Cowell, E M Air Raid Abdominal and Pelvic Injuries Lancet, 1, 469, 1939
- ⁴⁰ Bergos Ribalta, F de A Unas notas sobre la cirugia de guerra Rev san de guerra, 2, 24, 1938
- ⁴¹ Shipley, A M, and Hamrick, J C Abdominal Catastrophes Resulting from External Violence Am Jour Surg , 42, 542, 1938
- ⁴² Taylor, F W Gunshot Wounds of the Abdomen Jour Indiana Med Assn , 31, 342, 1938
- ⁴³ Gordon-Taylor, G Abdominal Injuries and Their Recipients Brit Jour Surg , 26, 217, 1938
- ⁴⁴ Von Miorini, A Treatment of Gunshot Wounds under War-time Conditions Chinese Med Jour , 53, 477, 1938
- ⁴⁵ Wershub, L P Penetrating Wounds of the Abdomen New York Med Coll and Flower Hosp Bull , 1, 119, 1938
- ⁴⁶ Wright, Louis T, Wilkinson, Robert S, and Gaster, Joseph L Penetrating Stab Wounds of the Abdomen and Stab Wounds of the Abdominal Wall Review of 184 Consecutive Cases Surgery, 6, 241, 1939
- ⁴⁷ Granger, Amedee Device for the Localization of Foreign Bodies by Means of the X-ray New Orleans Med and Surg Jour , 70, 585, 1918

- ⁴⁸ Kagan, B M Simple Method for Estimation of Total Protein Content of Human Plasma and Serum—Falling-drop Method Jour Clin Invest, 17, 373, 1938
- ⁴⁹ Bing, J Serum Protein Determination by Glass-bead Method Acta med Scandinav, 96, 403, 1938
- ⁵⁰ Eisberg, H B Diagnosis and Treatment of Penetrating Abdominal Wounds Am Jour Surg, 5, 145, 1928
- ⁵¹ Schoenberg, H B Subcutaneous Visceral Injuries New York Med Jour, 118, 500, 1923
- ⁵² Silleck, W M Penetrating Wounds of the Abdomen Am Jour Surg, 37, 3, 1923
- ⁵³ Winslow, Nathan Penetrating Abdominal Wounds Surg, Gynec and Obstet, 34, 617, 1922
- ⁵⁴ Davis, J W Gunshot Wounds of the Liver Mil Surg, 77, 239, 1935
- ⁵⁵ Oberhelman, H A, and LeCount, E R Peace-Time Bullet Wounds of the Abdomen Arch Surg, 32, 373, 1936
- ⁵⁶ Condict, W L Perforated Gunshot and Stab Wounds of the Abdomen—Treated at Gouverneur Hospital, New York ANNALS OF SURGERY, 80, 51, 1924
- ⁵⁷ Ochsner, Alton, and DeBakey, Michael Effect of Insulin and Glucose on Normal and Obstructed Intestine, Proc Soc Exper Biol and Med, 29, 264, 1931
- ⁵⁸ Waters, R M Study of Morphine, Scopolamine, and Atropine, and Their Relation to Preoperative Medication and Pain Relief Texas State Jour Med, 34, 304, 1938
- ⁵⁹ Prey, Duval, and Foster, J M, Jr Gunshot Wounds of Abdomen Review of 22 Cases ANNALS OF SURGERY, 99, 265, 1934
- ⁶⁰ Billings, Arthur E, and Walking, Adolph Penetrating Wounds of the Abdomen ANNALS OF SURGERY, 94, 1018, 1931
- ⁶¹ Furniss, H D Instrument for Intestinal Anastomosis Am Jour Surg, 23, 379, 1934
- ⁶² Shambaugh, P, and Dunphy, J E Postoperative Wound Infections and Use of Silk An Experimental Study SURGERY, 1, 379, 1937
- ⁶³ Hartzell, John B Treatment of Fistula of the Small Intestine Surg, Gynec and Obstet, 66, 108, 1938
- ⁶⁴ Snyder, H E Postoperative Atelectasis ANNALS OF SURGERY, 102, 5, 1935
- ⁶⁵ Cutler, E C, and Hunt, A M Postoperative Pulmonary Complications Arch Surg, 1, 114, 1920
- ⁶⁶ Sante, L R Massive (Atelectatic) Collapse of Lung—Especial Reference to Treatment, J A M A, 88, 1539, 1927
- ⁶⁷ Henderson, Y The Physiology of Atelectasis J A M A, 93, 96, 1929
- ⁶⁸ Gruber, C M, and Robinson, P I Intestinal Activity in Unanesthetized Dogs as Influenced by Morphine and Papaverine Jour Pharmacol and Exper Therap, 37, 101, 1929
- ⁶⁹ Ochsner, Alton, Gage, I M, and Cutting, R A The Value of Drugs in the Relief of Ileus Arch Surg, 21, 924, 1930
- ⁷⁰ Fine, J, Banks, B M, and Hermanson, L Treatment of Gaseous Distention of the Intestine by Inhalation of 95 Per Cent Oxygen Description of an Apparatus for the Clinical Administration of High Oxygen Mixtures ANNALS OF SURGERY, 103, 375, 1936
- ⁷¹ Boothby, W M Oxygen Administration Value of High Concentration of Oxygen for Therapy Proc Staff Meet, Mayo Clinic, 13, 641, 1938
- ⁷² Lovelace, W R, II Oxygen for Therapy and Aviation Apparatus for the Administration of Oxygen or Oxygen and Helium by Inhalation Proc Staff Meet, Mayo Clinic, 13, 646, 1938
- ⁷³ Bulbulian, A H Design and Construction of Masks for the Oxygen Inhalation Apparatus Proc Staff Meet, Mayo Clinic, 13, 654, 1938
- ⁷⁴ Thorn, G W, Howard, R P, Emerson, K, Jr, and Firor, W M Treatment of Addison's Disease with Pellets of Crystalline Adrenal Cortical Hormone (Syn-

thetic Desoxy-corticoesterone Acetate) Implanted Subcutaneously Bull Johns Hopkins Hosp, 64, 339, 1939

⁷⁵ Vorhaus, M C Hypervitamin Therapy in Surgical Practice Am Jour Surg, 42, 350, 1938

⁷⁶ Steinberg, B Experimental Background and Clinical Application of Escherichia Coli and Germ Tragacanth Mixture (Coli-Bactragen) in Prevention of Peritonitis Am Jour Clin Path, 6, 253, 1936

DISCUSSION —DR RUDOLPH MATAS (New Orleans, La) It is unfortunate that Doctor Storck's valuable paper should have come up too late for adequate discussion Despite the great progress accomplished in abdominal surgery, penetrating, and especially *gunshot*, wounds of the abdomen still remain the gravest of our major hospital emergencies It is, therefore, fitting that our Association, representing as it does all that is distinctive or typical of the surgery of the South, should continue to be, as in the past, the repository of the collective and most authoritative experiences and opinions on this subject We are not only concerned in the problem surgically, but sociologically because the frequency of homicidal gunshot wounds, in general, and of the abdomen in particular, have contributed to establish our disgraceful reputation for uncontrolled "gun toting" and "most murderous nation in the world" I am particularly interested in Doctor Storck's paper because it reflects the present experience of the Charity Hospital of New Orleans, in which I have been deeply concerned as a visiting surgeon and teacher during the 47 years that I was active in its staff (1880-1927) and, as you see, am still interested despite my present consultant status

No one who is familiar with this hospital, or who has systematically studied its annual reports, can fail to be impressed by the extraordinary opportunities that it offers for the study of gunshot wounds, in general, and of the abdomen in particular

Interested in the sociologic, racial and surgical aspects of the subject, I undertook, in 1891, a statistical inquiry into the incidence of gunshot wounds in New Orleans with special reference to those of the abdomen, which up to that time had not been regarded as surgical Part of this material was contributed to Dr F Byron Robinson's Intestinal Surgery published the same year Again, in 1901, assisted by Mr Edward Hynes, we compared the prevalence of gunshot wounds of the abdomen with other institutions, and found that the admissions in the Charity Hospital for the decennium 1890-1900, alone, exceeded those of nine other general hospitals in Boston, New York, Philadelphia, Cincinnati and St Louis, for the same period, the combined hospitals totaling 205 cases against the Charity Hospital's 234 cases

The same evidence of our hospital's unenviable superiority in homicidal gunshot wounds was confirmed later in statistics collected for Major Lagarde's Military Treatise on Gunshot Injuries (1914) These statistical studies were particularly utilized for my lecture to military classes of the Medical Reserve Corps, established at the Charity Hospital under my direction by the Surgeon General, in 1917-1918, but the teaching value of this material was more fully exhibited in my report of 1925-1926, as Chairman of the Committee on Gunshot Wounds of the Abdomen appointed by the Staff, which showed that in 35 years (1890-1925) 1,175 patients with penetrating gunshot wounds of the *abdomen* had been admitted to the hospital, with an *average* annual mortality of 60.52 per cent

Keeping pace with the growing population of the hospital, of the city, and of the surrounding country, the admissions for gunshot wounds in general, for the 24 years, 1904-1928, amounted to 6,075 gunshot wounds, with 1,284

deaths—including 60 per cent in Negroes. It is not surprising that Major Lagarde jokingly suggested that the students in the Army Medical School should come to the Charity Hospital for part of their military training.

From 1928 to 1939, 11 years, the general ratio of gunshot wounds, including those of the abdomen, to the hospital admissions has diminished slightly, because the admissions to the Charity Hospital were restricted to Louisiana citizens and there is less "dumping" of out of town patients into New Orleans. The mortality has also apparently diminished, as shown by Doctor Storck, but it is still fearfully high—despite transfusions and prompt surgical aid. The penetrating stab wounds, classically, retain their comparatively benign character. In a hurried survey, I find that, during 1934–1935, combined *gunshot* and *stab* penetrating wounds of the abdomen numbered 55, *gunshot* cases operated upon, 32, with a mortality in 14 instances or, 47 per cent. *Stab* wound cases numbered 23, resulting in eight deaths, or a mortality of 34.89 per cent. 1935–1936, total gunshot and stab wounds, 63, gunshot operated upon, 38, a mortality of 36.82 per cent. Stabs, 25, dead, five, a mortality of 20 per cent. The graphic representation of the mortality according to the organs involved, and the classification of other factors in the mortality, is excellent. Having lived through the early period of the 80's, when nonintervention was the rule in gunshot wounds of the abdomen, I participated in the controversies and polemics of the "abstentionists" and "interventionists," which alternately fluctuated in the practice of the hospital, in accordance with the opinions and dicta of the resident house surgeons who tenaciously controlled the Emergency Service as their special prerogative. Despite the success of Dr. A. B. Miles, who inaugurated the operative treatment of these wounds, March 8, 1891, and that this Association had unanimously adopted a resolution moved by Dr. Howard Kelly, in 1896, to the effect that "in gunshot wounds of the abdominal cavity, the proper routine procedure is to make an immediate laparotomy incision," we see that as late as 1905, the majority of the penetrating gunshot wounds of the abdomen were treated medically, solely by rest, starvation and opium or morphine, hypodermoclysis or saline intravenous infusions.

It would be interesting to follow progress of events and note the names of the distinguished men—chiefly Fellows of this Association—who, during the last half century, gradually stabilized the principles which at present govern the treatment of these ever formidable injuries. The surgeons of to-day, who depend solely upon the printed literature for information on the history of that transition period, miss much unpublished statistical information and particularly the animation and even acrimony that pervaded some of these discussions. But the time is too limited to do more than stress the enormous importance of the experience of hospitals such as the Charity, at New Orleans, in directing and fashioning the practice of the military surgeons at the front, in the surgical problems of actual warfare, which at this moment compel universal attention.

The time for the surgical study of gunshot and other war wounds was never more opportune than at present, now that, in the clash of contending armies, countless thousands are falling hourly everywhere on the battle fronts of Europe and China from the effects of wounds inflicted by the most varied weapons and in the most diverse circumstances. With this in mind, I have prepared a synoptic glance at abdominal gunshot wounds in the late civil war in Spain, a task which has been much simplified by the publication of the carefully prepared reports of the Spanish Military Surgeons on both sides of the conflict, but particularly the Nationalist (Franco's) Surgeons who have recorded and analyzed their experience in dealing with over 1,500 gunshot

wounds of the abdomen inflicted by all variety of missiles in all imaginable conditions, and, often heroic, circumstances in which they exercised their surgical duties. As it is obviously impossible in this limited space to quote details, I will condense the information obtained from the official military journals on both sides and from my personal observation while in Spain. I will endeavor to convey the general trend of the conclusions by a few generalizations gleaned from the very recent reports of Dr. Nicolas Canto, A. J. Baion, F. Cuadiado and G. Roldan of General Franco's Nationalist armies, and from the publications of Doctors Bastos, Beigos, and D'Harcourt in the official journal of the Republican Staff at Barcelona. As the methods of treatment were practically the same in both armies, the general conclusions arrived at by Dr. A. G. Baion (*Revista Espanola de Med. y Cir. de Guerra*, 2, No. 9, 219-234, March, 1939) will serve as a sample of the general surgical experience of the Spanish Civil War. Of 500 well recorded abdominal wounds, 239 (47 per cent) were regarded as inoperable and were not celiotomized because (a) they were brought from the field in a hopeless, dying condition. In this group there were 192 of the wounded, of whom 97 per cent died, (b) in 47 of the nonoperated group, no celiotomies were performed because the visceral lesions were limited to the liver and it was thought that they had a better chance of survival without operation. The mortality in this group was 19 per cent, thereby confirming the good judgment of the surgeons in not operating. (2) Celiotomies were performed for penetrating gunshot wounds in 261 patients (52 per cent of the 500 admissions), on an average of seven and one-half hours after the injury had been inflicted. In 22 of these celiotomized patients, the lesions involved, almost exclusively, the parenchymatous organs, especially the liver, and, in this group there were 47 per cent recoveries, or a mortality of 54 per cent. (3) Two hundred forty were celiotomized for lesions of the gastro-intestinal tract, alone or conjointly with other visceral wounds. In this group only 25 per cent recovered and 75 per cent died. (4) Not included in these 500 cases were 22 exploratory celiotomies for penetrating and nonpenetrating, uncomplicated visceral injuries, the mortality in this group was 55 per cent. In addition, there were 16 patients with possibly penetrating, but, seemingly, uncomplicated wounds. In this group the mortality was only 6 per cent. (5) The great increase in artillery warfare, machine guns, explosive shells, shrapnel, hand grenades, aerial bombs, trench mortars, etc., has increased the mortality of the abdominal wounds by their multiplicity and wider range of destructive action and complications (Roldan). (6) The number of fatally wounded who survived long enough from the shock and hemorrhage on the battle field to reach the casualty stations in a moribund and hopeless condition is increasing (35-47 per cent) (Baion). This is particularly characteristic of trench warfare, when the fatally wounded patients die on the field if delayed in transportation, but survive just long enough to expire in the field hospitals when the distance is short and the stretcher bearers are promptly on the spot. (7) Despite the best care and skill, the mortality of *exploratory* celiotomies is still high, 37 per cent. (8) It would seem that, despite the free and abundant resort to transfusion with whole or preserved blood, and despite favorable conditions for operation, the mortality in perforating wounds of the *gastro-intestinal* tract still remains high, 75 per cent. (9) The mortality of gunshot wounds of the abdomen involving the gastro-intestinal tract shows relatively little improvement over the mortality of the same wounds recorded in the experience of the allied French, British and American surgeons, or of German operators at the close of the World War, which was largely a stabilized trench war with surgical dugouts close by. (10) Undoubtedly, exposure in freezing temperatures, delay in

transportation, starvation, hasty mobilization of the surgical staff, and patients in mobile wars exercise a very decided influence upon the prognosis, all of which was well exemplified in the freezing winter temperatures at Teruel, the Ebro, Segre and the Pyrenean slopes (11) It would seem that the increasing destructiveness of contemporary warfare, particularly in the multiplied and diversified phases of artillery fire, on land, air and sea, offsets and counteracts the inadequate life-saving efforts of surgical science (12) For example, Baron quotes approvingly of Goetze's statement (1929) that "theoretically we may say that under optimum conditions of surgical technic and transportation, in warfare, it is possible to save 25 to 30 per cent of the penetrating wounds of the abdomen, who would be doomed to certain death without operation" But "when we face the cruel realities of the World War, as they apply to our [Spanish] experiences, we see that while it is true that from 1,850 to 3,700 abdominally stricken soldiers owe their lives to timely surgery by celiotomy, we also realize the relative insignificance of our contribution when we calculate that 10 per cent of the 1,185,000 soldiers killed outright on the battle fields of the World War were caused by the shock and hemorrhage of penetrating abdominal wounds' The disproportion of those saved by surgery and killed is the more apparent when we consider that fully 10 per cent of 1,185,000 killed in battle is equal to 118,500 abdominal deaths on the battle field, before any surgical assistance can possibly reach the stricken men"

BIBLIOGRAPHY OF RECENT SPANISH WAR LITERATURE ON ABDOMINAL WOUNDS

- Canto Borreguero, Nicolas Our Experience in Abdominal Wounds Rev Esp de Med y Cir de Guerra, Ano II, Valladolid, Tomo 2, No 5, 1-8, January, 1939
- Baron, A G Immediate Results Obtained in the Field Hospitals at the Front, in the Treatment of Penetrating and Complicated Abdominal War Wounds Rev Esp de Med y Cir de Guerra, Ano II, Valladolid, Tomo 2, No 7, 213-224, March, 1939
- Idem* Selection of the Type of Incision in Laparotomy for War Wounds of the Abdomen, Based on an Analysis of 269 Laparotomies for Abdominal War Wounds Rev Esp de Med y Cir de Guerra, Ano II, Valladolid, Tomo 2, No 9, 361-372, May, 1939
- Cuadrado, Fernando Ways of Access to Intraperitoneal War Wounds, Based on 207 Laparotomy Incisions for War Wounds Rev Esp de Med y Cir de Guerra, Ano II, Tomo 3, No 14, 267-278, October, 1939
- Duran, Gomez Fundamental Principles in War Surgery (Includes Abdominal War Wounds) Rev Esp de Med y Cir de Guerra, Ano II, Valladolid, Tomo 3, No 11, 1-35, July, 1939, Tomo 3, No 12, 81-101, August, 1939
- Sevilla, Constantino Roldan Abdominal Surgery in Warfare Rev Esp de Med y Cir de Guerra, Ano II, Valladolid, Tomo 3, No 11, 66-72, July, 1939
- Bastos, M On the Prognosis of Abdominal War Wounds Revista de Sanidad de Guerra, Ano 1, Barcelona, No 9, 1-9, January, 1938
- Bergos, Ribalta, F de A Notes on the Surgery of War (Includes a Discussion on Abdominal War Wounds) Rev de San de Guerra, Ano 1, Barcelona 2, No 9, 24-46, January, 1938
- Baron, A G Spontaneous Pneumoperitoneum in Penetrating and Complicated Abdominal War Wounds Rev Esp de Med y Cir de Guerra, Ano II, Valladolid, Tomo 3, No 13, 173-189, September, 1939

DR R. A. GRISWOLD (Louisville, Ky) I do not know whether the ice-pick is used in New Orleans or not In Louisville it is the most lethal of all our hand-to-hand weapons A knife usually breaks on the second or third stab but an ice-pick does not We get a large number of multiple ice-pick

wounds, and we are not operating upon those of the abdomen except where there is evidence of hemorrhage

Ice-pick wounds of the bowel are like birdshot wounds, in that the hole is so small that the mucosa does not evert. Consequently, leakage of intestinal content is minimal or absent and these wounds will heal themselves.

In looking over our cases of abdominal wounds we were impressed with the fact that we were performing a considerable number of unnecessary celiotomies in those borderline cases in which penetration was suspected but was not certain. During the last year, Dr. Joseph Hamilton, of the Louisville City Hospital staff, has been using the peritoneoscope in some of these borderline cases. By this means he can explore the peritoneum beneath the suspected wound, and can determine the presence or absence of penetration or of blood or intestinal contents in the peritoneal cavity. This procedure has eliminated a considerable percentage of unnecessary major celiotomies for suspected penetrating wounds of the abdomen.

FACTORS OF MORTALITY IN 4,000 OPERATIONS UPON THE EXTERNAL BILIARY SYSTEM*

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FROM January 1, 1920, to June 30, 1937, the diagnosis of gallbladder disease was made on 5,200 consecutive patients. Of this number, 3,986 were treated surgically and 309 individuals died, representing a basic mortality of 7.7 per cent. The gross mortality included every death that occurred while the patient was in the hospital irrespective of its cause.

It is not without interest, that in the 17½ years represented by this study there were two major rotations of the Surgical Staff at the Post-Graduate Hospital. The attending surgeons represented during the decade beginning 1920 were, with one exception, not on service at the beginning of 1930. The author's initial contribution to this series began in 1920, and now represents approximately one-fifth of the material studied.

An analysis of this group of now over 4,000 surgical patients was made to determine what the factors were that determined the mortalities. How many of these 309 deaths could be attributed to the calamities of surgery—the accidents, the complications over which the surgeon could exercise no control, such as embolism, apoplexy and coronary thrombosis? What mortalities were due to the unconquerable nature of the disease—the malignancies, or the patient's refusing surgical intervention at the most opportune time, or to the enfeebled condition of the patient from the ravishes of prolonged disease? What mortalities were due to lack of diagnostic skill, or to multiple surgery, or to lack of care and equipment or the insufficiency of scientific knowledge, such as the absence of vitamin K as the controlling factor of post-operative bleeding in jaundice? What were the mortalities that may be ascribed to derelictions of surgical judgment, and what mortalities were due to lack of technical skill or inadequacy of pre- and postoperative treatment?

The 309 mortalities were the responsibility of some 53 surgeons, while 64 of the deaths among 574 cases of acute cholecystitis were the responsibility of 31 surgeons. The study emphasizes that gallbladder disease is a continuing and progressive condition. Again and again, one is impressed with the progressive character of the infective process. Primary disease in the gallbladder, with or without calculus, is followed by the development of obstructive symptoms of the cystic duct and, later, disease of the common and hepatic ducts and, finally, the development of varying types of pancreatitis and liver

* The statistical data included in this communication were studied in collaboration with Dr R Franklin Carter and Dr Richard Hotz.

Read before the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga, December 5, 6, 7, 1939.

disease In general, the mortality statistics of this series correspond approximately to those of the 36,623 biliary tract operations collected by Heuer, with a gross mortality of 6.6 per cent In a personal series of 557 operated cases, it was found that cholecystitis was associated with ulcer of the stomach and duodenum in 10.5 per cent, with jaundice in 16.3 per cent, with pancreatitis in 3.7 per cent, and with fibroids in 1.3 per cent The percentage of females to males was three to one Diabetes was present in 0.89 per cent of the patients at the time of operation, and malignancy occurred in 2.3 per cent of the cases

If a sufficiently large number of individuals with gallbladder disease were studied, one can interpolate a series of charts indicating a progressive advancement in the pathologic invasion, a rise in the severity of the symptomatology, and an almost geometric progression in mortality With but few exceptions, disease of the gallbladder arises in the gallbladder, and the initial infectious process is located beneath the serosa and in the wall of the gallbladder Depending upon the virulence of the infecting organism, the resistance of the individual, and incidental and local conditions—diet, general metabolism, *etc*—there is produced a simple type of cholecystitis which constitutes the largest number of cases for surgical intervention Calculi were present in the gallbladders of 69 per cent of 3,306 patients operated upon for chronic cholecystitis If the pathologic process continues unrelieved by surgery, there will ensue secondary changes in the cystic duct, the common and hepatic ducts, and eventually an infective process will involve the entire extrahepatic system Stones in the common duct were found in 6.9 per cent of the cases of chronic cholecystitis but were present in 17 per cent of the cases of acute cholecystitis, and were found in 80 per cent of all secondary common duct operations following cholecystectomy Calculi were present in the gallbladder in 89 per cent of the cases of acute cholecystitis

Cholecystectomy alone, or with appendectomy, was performed for chronic cholecystitis 2,438 times with a mortality of 3.61 per cent Cholecystectomy was combined with choledochostomy in 7.7 per cent of the cases with a mortality of 11.34 per cent When gallbladder disease is complicated by common duct involvement the mortality is raised from 3.61 to 11.34 per cent The mortality risk inherent in surgery upon the common duct is more than three times greater than the risk of simple, uncomplicated cholecystectomy (Table I) An interesting sidelight is shown in this group of cholecystectomy with common duct disease, for in the group of common duct cases with stones the mortality was 12.8 per cent, while among the cases that had common duct exploration and drainage, but were without calculi, the mortality was 3.8 per cent, not materially higher than simple cholecystectomy alone—where the mortality was 3.61 per cent In brief, 7.7 per cent of the cases with cholecystectomy had common duct drainage, and 86 per cent of these cases had calculi in the common duct, with a mortality of 12.8 per cent, 14 of the 7.7 per cent had the common duct drained but no calculi were found, with a mortality of 3.8 per cent

TABLE I

ANALYSIS OF 3,986 CONSECUTIVE OPERATIONS UPON THE BILIARY TRACT (1920-1937)

Operation	No of Cases	Mortalities	Mortality Per Cent
Chronic Cholecystitis			
Cholecystectomy	3,240	190	5 8
Alone or with appendicectomy	2,438	88	3 61
With dochostomy	238	27	11 34
With other operation	568	74	13 03
Cholecystectomy with dochostomy and other operations	6	1	16 16
Cholecystostomy	66	22	33 3
Alone or with appendicectomy	43	13	30 24
With dochostomy	16	6	37 50
With other operation	7	3	42 80
Totals	3,306	212	6 40
Obstructive Biliary Disease			
Cholecystogastrostomy	52	15	28 8
Choledochostomy only	37	13	35 1
Choledochostomy with other operations	2	2	100 0
Plastic on ducts	5	3	60 0
Total obstructive	96	33	34 4
Acute Cholecystitis			
Cholecystectomy	517	45	8 82
Alone or with appendicectomy	428	32	7 47
With dochostomy	89	13	14 60
Cholecystostomy	45	13	28 80
With dochostomy	9	3	33 33
Total cholecystostomy (with 3 other operations)	57	18	29 63
Total acute cholecystitis	574	64	10 97
Total for all biliary tract operations	3,986	309	7 7

Of the 3,306 operations for chronic cholecystitis, cholecystostomy was performed only 66 times, with a mortality of 33.3 per cent. This operation represented only 2 per cent of the total operations for chronic gallbladder disease. Ninety-six operations were performed for gross obstructive biliary disease, with a gross mortality of 34.4 per cent. Cholecystogastrostomy was performed 50 times, and cholecystoduodenostomy twice, with a mortality rate of 28.8 per cent. Thirty-six of the 52 anastomotic operations were for carcinoma and 16 for obstructive pancreatitis.

Thirty-nine patients entered the hospital after having had a cholecystectomy performed elsewhere. Six of the patients had had a cholecystectomy performed at the Post-Graduate Hospital. Of these 39 patients admitted, and reoperated upon, 32 of the group had recurrent or overlooked stones in the common duct. Seven had stenosis of the common duct, and choledochostomy was performed upon all 39 patients, with a mortality rate of nearly 40 per cent.

Multiple surgery is one of the most outstanding factors in increasing the mortality rate. In 575 operations cholecystectomy was combined with one or more other operative procedures, with an average mortality of 13.85 per cent, nearly four times higher than cholecystectomy alone, 3.61 per cent. These "secondary" operations were inherently dangerous, and carried their own mortality rate if performed as a single operation, namely, acute gangrenous appendicitis, gastroduodenal ulcerations, fibromyoma of the uterus, etc (Table II).

TABLE II
CHRONIC CHOLECYSTITIS

Factors Influencing the Morbidity and Mortality in Surgery for Chronic Cholecystitis

	No of Cases	Morbidity	Mortality Per Cent
(A) Multiple Surgery (cholecystectomy plus secondary operation)	575	1.72	13.85
1 With gastro-enterostomy	128		16.4
2 With pyloroplasty	111		9.9
3 With gastric resection	61		31.1
4 With acute appendix	31		13.0
5 With hysterectomy	59		11.8
(B) Conservative Treatment in Acute Cholecystitis			
1 Subsided acute	474	1.59	11.02
2 With chronic abscess or old perforation into colon	46	2.20	38.0
3 Cholecystostomy in previous acute	15	1.58	20.0
(C) Cholecystostomy in Chronic*	68	1.50	7.4
(D) Jaundice (especially necessitating common duct surgery)	254		13.0
(E) Delay in Surgery for Chronic Cholecystic Symptoms (series with less than two years' history)	959		1.35
Total series of chronic cholecystitis	3,303	1.31	6.4

* Means cholecystostomy for a previous chronic infection—now followed by a cholecystectomy.

Three hundred of the 575 multiple operations were for concomitant disease in the gastroduodenal segment. Only 24 were for associated malignancy of the stomach. Thus 9 per cent of the operations performed for chronic cholecystitis had surgery for associated gastroduodenal pathology, mainly ulcer. How adversely the addition to cholecystectomy of operations upon the stomach affects the mortality can readily be seen in Table II. Cholecystectomy plus pyloroplasty had a mortality of 9.9 per cent. Cholecystectomy plus gastro-enterostomy had the disproportionately high mortality of 16.4 per cent. With gastric resection added to a cholecystectomy the mortality rate was 31.1 per cent. The association of chronic cholecystitis with ulcer of the stomach and duodenum is receiving increasing attention in the current literature. That this association in surgery carries a prohibitive mortality in a large series of cases is, therefore, of great importance.

Thirty-one patients had their gallbladders removed in the presence of a pathologically acute appendix, and in four of these the appendix was perforated. The mortality rate was 13 per cent. In no instance was the gallbladder acute, though in the majority of instances it showed advanced pathology. The mortality rate of 11.8 per cent, where hysterectomy and cholecystectomy were performed, is further evidence that the patient with cholecystitis cannot well tolerate additional surgery.

The chronicity of the biliary disease was a most important factor in mortality, as is evident from the fact that among 3,306 operations for chronic cholecystitis, 959 of the patients had definite symptoms of less than two years' duration, and without any evidence of a previous acute attack. These patients had no other surgery except the cholecystectomy, with or without appendectomy. The average age of the group was 43 years, as contrasted with the mean age of 47 years in the larger group. Only 13 deaths occurred among these 959 patients, a mortality rate of 1.35 per cent, in contrast with the general mortality of the cholecystectomy group of 3.61 per cent. There were 311 patients in whom definite symptoms had been present less than two years, but who gave a history of previous acute attacks or had secondary operations with a cholecystectomy. This group had 22 deaths, or 7.10 per cent mortality (Table III).

TABLE III

AN ANALYSIS OF THE RESULTS OF OPERATION IN CHRONIC CHOLECYSTITIS
WHEN DEFINITE SYMPTOMS HAVE BEEN PRESENT LESS THAN TWO YEARS

	No of Cases	Mortalities	Mortality Per Cent
Uncomplicated cases	959	13	1.35
Complicated*	311	22	7.10
Total operations	1,270	35	2.75
Causes of Death		Major Complications	
Pneumonia	11	Wound infections (severe)	23
Peritonitis	10	Dehiscence	15
Liver death	4	Pneumonia	8
Cardiac failure	4	Thrombophlebitis	5
Operative shock	3	Postoperative hemorrhage	4
Postoperative hemorrhage	2	Pleurisy (effusion)	3
Uremia	1	Cardiac failure	3
		Surgical erysipelas	1
		Peritonitis	1
		Acute parotitis	1

* Those with previous acute attacks or with secondary operations

Jaundice, in any degree, was a most impressive factor in the increased mortality in chronic cholecystitis, for in 254 patients with jaundice at the time of operation, the mortality rate was 13 per cent, and 86 per cent of these patients had stones in the common duct.

Of the 3,306 patients operated upon for chronic cholecystitis, 474 gave a definite clinical history of having had a previous acute attack, and there was a definite correlation between the history and the pathologic report in 87.7 per cent (Table IV). Forty-six cases of perforation of the gallbladder occurred in so-called chronic cholecystitis, with a mortality of 19.5 per cent. Nine of these had perforations into the colon. They are included in the 474 cases reported above.

TABLE IV

THE INCIDENCE OF PERFORATED CHOLECYSTITIS

In Patients Who Have Recovered from Acute Attack and Are Subsequently Operated upon, and the Incidence in Operated Acute Cholecystitis

Pathology (Microscopic Diagnosis)	No. of Cases	Per Cent Perforated	Mortality Per Cent
Chronic cholecystitis (previous acute attack)	474		11.2
"Chronic" perforated cholecystitis	46	9.7	19.5
Acute cholecystitis	574		10.97
Acute perforated cholecystitis	69	12.1	26.1
	<hr/>	<hr/>	<hr/>
Total cases of perforated cholecystitis	115	11.0	24.3

Cholecystostomy for chronic cholecystitis proved to be inadequate. Sixty-eight patients, after a cholecystostomy, were subsequently operated upon for recurrence of symptoms, with a mortality of 7.4 per cent, as contrasted with a mortality of 3.61 per cent for primary, noncomplicated cholecystectomy. In the Follow-Up Clinic, 54 per cent of the patients with cholecystostomy had a continuation or recurrence of symptoms. Among this group of 68 patients, 77 per cent had recurrent or overlooked calculi at the second operation.

There were 574 cases of acute cholecystitis, and the diagnosis of acute cholecystitis was made by the pathologist, after an examination of the gallbladders from 542 patients. In 32 cases no pathologic examination was made as these patients had a cholecystostomy but are classified as acute cholecystitis.

For purposes of analysis, the following pathologic designations were made: Acute cholecystitis, purulent cholecystitis, gangrenous cholecystitis, perforation with abscess, perforation with peritonitis. Acute cholecystitis included all of the cases that showed acute inflammatory change in the gallbladder but did not exhibit either empyema, gangrene or perforation. The mortality following operation in acute cholecystitis was 5.85 per cent. The mortality for purulent cholecystitis was 9.4 per cent—a higher mortality than occurred in the group with gangrenous cholecystitis, where it was 7.33 per cent. It is interesting to note that of the 574 cases, 32 had cholecystostomy and were without any pathologic report, and the mortality was 34.4 per cent, almost equivalent to the mortality of acute cholecystitis with perforation and peritonitis, namely, 35.85 per cent (Table V).

TABLE V
ACUTE CHOLECYSTITIS
Pathologic Analysis of 574 Operations
(Summary)

Pathologic Diagnosis	No of Cases	Per Cent of Total	Mortality Per Cent
Acute cholecystitis	206	36 0	5 85
Purulent cholecystitis	117	20 4	9 40
Gangrenous cholecystitis	150	25 9	7 33
Perforated, with abscess	16	2 8	0 00
Perforated, with peritonitis	53	9 2	35 85
No pathologic report	32	5 7	34 40
Total cases	574	100 0	10 97

Cholecystostomy for acute cholecystitis was not an unmixed blessing, as even when the patients recovered from the primary operation, subsequent surgery for the retained gallbladder gave a mortality of 20 per cent.

Operations for acute cholecystitis constitute 14.5 per cent of the surgery. Thirty-six per cent of the total acute cases were classified pathologically as acute cholecystitis and 64 per cent were classified as severe acute cholecystitis. Fifty-three of the 574 cases had a free perforation with peritonitis.

The presence of calculi in the acute gallbladder did not materially increase the mortality. In chronic cholecystitis calculi were present in 69 per cent of the cases, whereas 89 per cent of acute cholecystitis had calculi. Seventy-six per cent of the acute gallbladders had clinical and pathologic evidence of a previous chronic inflammation. Of great significance was the fact that of 316 cases observed in the hospital for 18 hours or longer, 57 per cent had a progression of their symptoms and of the physical findings, 31 per cent followed a static course, while 12 per cent only, definitely subsided (Table VI).

TABLE VI
AN ANALYSIS OF THE CLINICAL COURSE OF DISEASE IN 316 CASES
OBSERVED IN THE HOSPITAL FOR 18 HOURS OR MORE

Apparent Clinical Course of Disease	No of Cases	Per Cent of Total	Mortality Per Cent
Progressive	180	57	19 3
Static	100	31	7 0
Remissive	36	12	0 0

The mortality in acute cholecystitis was remarkably influenced by preoperative hospital treatment (Table VII). In the patients that were considered "emergency" (128), and were operated upon within six hours of their admission, the mortality was 15.6 per cent, but the patients (297) that were prepared from six to 24 hours had a mortality of less than half of the previous group, namely, 7.4 per cent. Further preoperative treatment in the hospital did not improve the mortality statistics, for 56 patients operated upon from 24 to 48 hours after admission had a mortality of 10.35 per cent,

and 93 patients operated upon from 48 hours to 24 days after their acute attack had a mortality of 17.6 per cent (Table VII)

TABLE VII

THE MORTALITY AND MORBIDITY IN ACUTE CHOLECYSTITIS IN RELATION
TO THE LENGTH OF PREOPERATIVE HOSPITALIZATION

Duration of Observation Period	No of Cases	Per Cent Perforated	Mortality Per Cent
0-6 hours	128	10.0	15.6
6-24 hours	297	13.1	7.4
24-48 hours	56	8.6	10.35
2-24 days	93	12.8	17.60
Totals	574	12.1	10.97

It may be assumed, therefore, that an immediate operation for an acute cholecystitis—that is, an operation within six hours after admission—is seldom indicated. Adequate preoperative treatment from six to 24 hours is sufficient to insure the best mortality statistics. The mortality rate after a few hours of preoperative therapy is slightly under that of the entire group mortality, 7.41 per cent, as contrasted with 7.7 per cent. Again, the lethal influence of jaundice becomes apparent in acute cholecystitis. Jaundice at the time of operation for acute cholecystitis increased the operative hazard, for 155 patients with acute cholecystitis complicated by jaundice were operated upon, with a mortality of 20.6 per cent, and in the patients who had acute cholecystitis but were not jaundiced at the time of their operation, but had a history of previous attacks with jaundice, the mortality among 101 patients was 15.8 per cent, contrasted with the basic mortality group of the acute cholecystitis cases operated upon between six and 24 hours, namely, 7.41 per cent.

There were 820 patients upon whom a pathologic diagnosis of mild cholecystitis was made. Many of these showed cholesterosis. Whether cholesterosis is essentially a pathologic condition is still a subject of considerable controversy. In any event, the mortality rate in this group was 1.34 per cent. The next degree in pathologic sequence indicates a disease of the gallbladder with definite infection and inflammation. The clinical symptoms become more apparent. Many of the patients have colic, and a diseased gallbladder can be readily determined by drainage and roentgenologic examination. The majority of gallbladder patients come to surgery at this stage of their disease. The mortality rises to 4.2 per cent, and the number of severe complications is doubled. The infection in the gallbladder will continue, and attacks of acute cholecystitis are apt to occur. In this group there were 474 patients operated upon for chronic cholecystitis who had clinical and pathologic evidence of former acute attacks. The operative mortality in this group was 11.20 per cent (Table VIII). Each succeeding acute attack increases the mortality by 2 per cent.

TABLE VIII

ANALYSIS OF 474 PATIENTS OPERATED UPON AS CHRONIC CHOLECYSTITIS WHO
HAD CLINICAL AND PATHOLOGIC EVIDENCE OF A FORMER ACUTE ATTACK

Pathologic diagnosis of former acute attack	474
Average total duration of chronic history	9 years
Average time since last acute attack (history and clinic record)	2 8 months
Mortality rate	11 20%
Morbidity factor	1 59%

The common duct pathology found in the series falls into two groups (1) Those conditions intrinsic to the duct, and (2) those extrinsic to it. Common duct stone was by far the most common cause for surgery upon the common duct. Choledochostomy was performed with cholecystectomy or cholecystostomy for chronic disease in 260 instances and stones were found in 82 per cent. In 3,306 operations for chronic cholecystitis, the incidence of common duct surgery was 77 per cent, and of stones, 69 per cent. Calculi were found in the common duct in 80 per cent of all secondary common duct operations after cholecystectomy. The invariable pathologic finding was an associated severe cholecystitis. This advanced pathology of the gallbladder found in common duct disease lends authority to the assumption that intrinsic common duct disease is usually secondary to gallbladder disease. That cholecystitis is a progressive disease which eventually involves the common duct has been noted repeatedly in our series.

TABLE IX

DURATION OF CHOLECYSTIC SYMPTOMS IN COMMON DUCT STONE

Duration of Symptoms	No. of Cases	Common Duct No. of Cases	Per Cent Common Duct Stone
Under 2 years	1,270	24	1 9
2-10 years	1,020	92	9 0
10-35 years	610	97	16 0

The relationship of calculi in the common duct to the duration of cholecystic symptoms is indicated in Table IX. In the 1,270 cases with symptoms of cholecystic disease of less than two years, there were 19 per cent with common duct stone. In 1,020 cases with symptoms from two to ten years, common duct stones were present in 9 per cent. In 610 cases with symptoms over ten years, 16 per cent had common duct calculi. Calculi in the common duct is presumptive evidence of delay in diagnosis or of surgical procrastination. In this series, 66 per cent of the cases with stones in the common duct were associated with chronic pancreatitis and chronic biliary disease. Acute pancreatitis was associated with common duct calculi in 78 per cent of the cases.

With the advent of cholangiography we have been able to exercise a more critical judgment. We have more confidence that there has been a complete restoration of function in the common duct and, furthermore, that the symptoms have been relieved and infection combated by adequate surgery.

The test is simple and readily carried out. The day before the test is to be made from 20 to 30 cc of normal saline is allowed to flow, by gravity, from a syringe into the T-tube. The common duct will ordinarily accommodate 20 or 30 cc, with practically no discomfort. On the morning of the following day, the patient is taken to the Roentgenographic Department and from 10 to 20 cc of sterile hippurin (50 per cent) is allowed to run into the T-tube. A roentgenogram is taken immediately at the completion of the injection. A second exposure is made four minutes later, and a third, eight minutes after the second roentgenogram, or 12 minutes after the injection. The first negative will indicate that both hepatic ducts are well filled with the solution and that the common duct is moderately distended. If the ampulla and common duct are totally unobstructed, the dye will have passed readily into the duodenum, and in four minutes may be observed in the duodenum and neighboring jejunal loops. The roentgenogram made at the end of 12 minutes will show almost complete evacuation of the dye into the small intestine.

Discussion—From this study there emerge certain very definite conclusions. It is evident that chronic biliary disease is a continuous and progressive pathologic condition, that the mortality and morbidity of this disease varies with the chronicity of the process itself, with the intrinsic pathologic changes, with the complications, and with the physical status of the patient. Surgery for chronic biliary disease is sufficiently dangerous to be the only operative procedure performed. The outstanding death-producing conditions in order of frequency were (a) Peritonitis, (b) pulmonary complications, and (c) varying states of hepatic insufficiency.

In regard to acute cholecystitis there is no warrant for what may be termed the "immediate" operation—that is, surgical intervention upon patients within six hours after admission to the hospital. The best results in acute cases, so far as mortality and morbidity are concerned, were obtained in the group of patients who were prepared for operation from not less than six hours up to 24 hours after their admission. Conservative treatment and watchful waiting, while they may appear temporarily successful, are eventually disastrous for the patient.

In the pathology of acute cholecystitis the mortality factor and the severity of the disease are increased when the patient has had previous attacks of icterus. Jaundice adds approximately 100 per cent to the mortality factor.

Cholecystostomy has a definitely higher immediate mortality than cholecystectomy, and has a more marked increase in the eventual mortality. Approximately 50 per cent of the patients with a cholecystostomy require reoperation, which carries with it a secondary mortality close to 20 per cent. The most successful results were obtained in the group of 959 patients who were operated upon within two years after definitely demonstrable gallbladder symptoms appeared. This low mortality, 1.35 per cent, was obtained regardless of the age of the patient, and is in contrast to the general cholecystectomy mortality of 3.61 per cent.

In the beginning of this series (1920) exploration of the common duct was

carried out only in the presence of very marked disease of the common duct or associated pancreatitis. As the precision of operative technic became thoroughly established, more common ducts were explored, with better results and less mortality. The importance of common duct disease and of primary exploration is apparent from a consideration of the statistics. Drainage of the common duct for cholangitis, calculous or otherwise, at the first operation, and when combined with cholecystectomy, does not give a prohibitive mortality (11.34 per cent), whereas a secondary choledochostomy in a previously cholecystectomized patient has a mortality approximately 350 per cent greater than that which attends primary exploration (38.60 per cent).

The visual and palpable findings that call for an exploration of the common duct are not always clear cut or well-defined. Cutler and Zollinger give the indications for exploration of the common duct at operation as follows: (a) The suggestion of a stone on palpation, (b) a dilated or thickened duct, (c) a contracted gallbladder, (d) a dilated cystic duct, (e) a thickening of the head of the pancreas, and (f) the presence of small stones in the gallbladder or the cystic duct.

We have been impressed with a disease of the common duct not characterized by the presence of calculi but exhibiting a markedly contracted common duct, with extensive fibrosis in the walls, with an associated palpable hardness of the head of the pancreas, and a history of attacks of slight jaundice (icteric index 25-30), febrile reaction and upper epigastric distress, even to the point of severe pain. This type of disease of the common duct has been found in patients who have had a primary cholecystectomy for chronic cholecystitis with cholelithiasis, and in periods varying from two to 12 years the patients have been reoperated upon for common duct disease.

THE IMMEDIATE AND END-RESULTS OF CHOLECYSTECTOMY*

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THE PURPOSE of this communication is to present a small group of patients who, following careful study, were operated upon for cholecystic disease. It is proposed to comment briefly upon the causes of the mortalities that occurred and, feeling that the ultimate destiny of the surgical patient is second in importance only to the immediate mortality rate, considerable effort will be made to evaluate, fairly and accurately, the final results obtained, and to attempt to determine the reason, or reasons, for the not inconsiderable number of unsatisfactory results that prevail. The study, it is hoped, may be of value, since essentially all of the patients being reported upon in this particular series lived in sufficiently close proximity to permit personal reexamination from time to time. It is felt, then, that the end-results recorded represent the true state of affairs. Also, the experiences and conclusions of certain other surgeons regarding the indications for, and results from surgery will be cited.

There can be little argument as to the very great frequency of gallbladder disease. Crump,¹ in a study of 1,000 consecutive autopsies in Vienna, found 33 per cent of the individuals to have gallstones and 60 per cent showed some form of cholecystopathy. Mentzer,² in a series of 612 autopsies at the Mayo Clinic, found 60 per cent of the subjects to have grossly pathologic, and 75 per cent microscopically pathologic changes in the gallbladder.

That the disease, while admittedly frequent in occurrence, is not frequently a cause of mortality is indicated by the report of Hoffman,³ statistician of the Prudential Life Insurance Company, who says that, in 1919, only 2,887 of a total of 85,147,822 persons died of gallbladder disease. It would seem from this study (in contradistinction to certain medical experiences to be later referred to) that death directly attributable to cholecystic disease is fairly rare. That happy state of affairs does not, however, exist in patients subjected to surgery. Macdonald⁴ recently found, after an international survey, that the average mortality, following surgical extirpation of the gallbladder, was 10 to 12 per cent. This figure is startlingly high (Table I), particularly so when compared with the experience of Barksdale,⁸ who reports 1.3 per cent mortality following cholecystectomy, of Elkin,⁷ who reports 2 per cent, of Sanders,⁵ who, among 1,000 consecutive patients, had a mortality of 2.5 per cent, of the Lahey Clinic,¹⁵ with a reported rate of 3.8 per cent, of Finsterer,¹¹ who reports 4.4 per cent, or of McGehee,⁶ who reports 7.2 per cent fatalities following all types of operative procedures upon the biliary tract. On the contrary, Boyd,⁹ in a series of 1,018 patients from the Massachusetts

* Read before the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

Memorial Hospitals, reports a mortality rate of 9 per cent following cholecystectomy for chronic inflammatory disease, and 11.4 per cent for cholecystectomy for cholelithiasis, or an average mortality rate of 10.5 per cent, a figure almost identical with that quoted by Macdonald as the average prevailing in a group of small, selected hospitals. Unfortunately, the vast majority of major surgical procedures performed in this country are executed by operators not possessed of the high grade of technical skill and excellent judgment of the surgeons just referred to, but are performed by the rank and file of the profession, many of whom are inadequately prepared to attempt such procedures. So long as that situation prevails, it is highly probable that the mortality rate the country over is, and will remain, decidedly higher than Macdonald's report indicates.

TABLE I

MORTALITY RATES FOLLOWING SURGICAL PROCEDURES UPON
GALLBLADDER AND DUCTS

Barksdale ⁵	13.1%
Elkin ⁷	2.0%
Sanders ⁸	2.5%
Lahey Clinic ¹⁰	3.8%
Finsterer ¹¹	4.4%
McGehee ⁶	7.2%
Boyd ⁹ —Mass Memorial Hospitals	10.5%
Macdonald ⁴ —Collected Series	10 to 12%

MORTALITY RATES FOLLOWING MEDICAL TREATMENT OF CHOLECYSTIC DISEASE

	Died	Cured	Im- proved	Unim- proved	Required Subsequent Surgery
Finsterer, ¹¹ 89 patients	12.3%	39%	40%	21%	
Schittinheim ¹² quoted by 11	25.0%				40.0%
Tallquist, ¹³ 110 patients	7.38%				21.8%
Jaguttes, ¹⁴ 114 patients	16.0%				22.8%

Mortality incident to medical treatment—16 to 25 per cent

That there exists at present a decided difference in opinion as to the ultimate results following removal of the gallbladder, can scarcely be denied. Many internists, and some surgeons, estimate that a very definite percentage of patients following surgery are either not benefited by the procedure or are actually made worse. Kunath,¹⁰ from the University of Iowa, reports that in the noncalculous group 69 per cent were cured or improved, and in the calculous group 84 per cent were cured or improved by cholecystectomy. Most large surgical centers feel that the end-results obtained are excellent. It seems, nonetheless, true that following cholecystectomy a definite number of individuals promptly die, and a large number fail to be benefited from the operation. Despite, however, the frequent comments of various internists concerning the poor results following cholecystectomy, there exists a striking

paucity of information from them concerning the end-results in patients treated medically. Before the results of surgical treatment are condemned or unduly criticized, the end-results accruing from, or attendant upon, medical treatment should likewise be analyzed. Finsterer¹¹ reports that, of 89 patients treated medically, 11 (12.3 per cent) died from gallstone trouble, seven died from perforation of the gallbladder, and two from carcinoma. Finsterer refers to other reports of series of patients treated medically, in which 39 per cent were completely or partially cured, 40 per cent were improved, and 21 per cent were unimproved. Schittenhelm¹² estimated that 40 per cent of patients discharged as "cured" following medical treatment had subsequent recurrence of attacks, and 25 per cent died or required surgery for severe complications. A study of surgical statistics shows that it is those very complications following ill-advised medical treatment that produce the majority of all surgical deaths. Tallquist¹³ studied 110 patients discharged as cured following medical treatment, and of these, nine died within six years of gallbladder disease, and 24 additional individuals later required surgery (with four deaths) on account of complications. Had the remaining "cured" patients been observed longer, more would likely have been found to have had further trouble. Jaguttis¹⁴ observed, from ten to 25 years, 114 patients treated medically. Of these, 13 died from gallstones, and five from cancer of the gallbladder, showing a total mortality of 16 per cent. An additional 26 had to be operated upon later because of the development of complications, from which group four died.

The above results, following medical treatment, do not compare favorably with the results following proper surgical management. The medical mortality in the series just quoted fluctuated from 16 to 25 per cent. The incidence of permanent recovery following medical treatment of genuine cholecystitis, and certainly of cholelithiasis, is hardly greater than the mortality rate that accompanies this form of therapeutics. It would appear from the literature available that the medical management of genuine cholecystic disease results in as many deaths as cures. Certainly that premise gains strength if we consider the grave complications which frequently follow such management for, as previously remarked, it is these very complications of medical treatment which, not rarely, make surgical intervention a necessity at a time not favorable for, and in an individual ill-prepared to tolerate, surgical attack. As an example of the latter may be cited the experience of Lahey,¹⁵ who reports a mortality rate of 7.6 per cent following choledocholithotomy with drainage of the duct, whereas for conditions not necessitating invasion of the duct the mortality rate is far lower. The conclusion of Finsterer, who believes that 87.8 per cent of patients are cured following cholecystectomy, is approximately that prevailing in most well-conducted surgical clinics.

It will be noted that in the personal series being presented (Table II), of the patients studied 23 per cent were male and 77 per cent were female. There was an operative mortality, including patients requiring removal of stones from, or repair of, the common duct, of 6 per cent. In calculating this mor-

tality rate, all patients who died previous to discharge from the hospital, irrespective of the immediate cause of their deaths, were included

TABLE II

DATA PERTINENT TO PERSONAL SERIES BEING PRESENTED

Total Number of Patients Studied—100

Sex— Male 23, Female 77

Total Deaths—6

Age	Sex	Jaundice	Diagnosis	Operative Procedure	Cause of Death	Time of Death
48	F	Yes	Gangrene of gall-bladder Peritonitis	Cholecystostomy	Peritonitis	25th p o day
57	F	Yes	Chr cholecystitis Cholelithiasis	Cholecystectomy	Peritonitis Ileus	12th p o day
68	M	Yes	Chr cholecystitis Cholelithiasis Choledocholithiasis	Choledocholithotomy Choledochostomy Cholecystostomy	Shock	24 hrs
55	F	No	Subacute cholecystitis	Cholecystectomy	Coronary occlusion	21st p o day
73	F	Yes	Empyema of gall-bladder Hepatic failure	Cholecystostomy	Hepatic failure	7th p o day
37	M	Yes	Hydrops of gall-bladder	Cholecystectomy	Hepatorenal failure	4th p o day

Patients jaundiced—26% (or definite history of previous jaundice)

Duct explored—16% Found to contain calculi or strictured—15

Patients jaundiced following surgery—1 or 1% (one transient attack only)

Patients requiring subsequent surgery for cholecystic disease—none

Surgical procedures employed—Cholecystectomy 93%

Cholecystostomy 7%

Choledochostomy 13%

Repair of stricture of common duct 1%

It is highly significant that, with a single exception, all patients who died following operation were jaundiced at the time of surgery. That particular individual, known prior to operation to have coronary artery disease, died of acute coronary closure, on the twenty-first postoperative day, at which time she was preparing to return to her home. It is even more interesting that none died as a result of postoperative bleeding, and, in fact, not one of the patients operated upon in this particular series had postoperative bleeding, although 11 per cent, at the time of surgery, were jaundiced, an additional 15 per cent had, on one or more occasions, been jaundiced, and 15 per cent, at surgery, were found to have common duct stones or stricture of the duct. It may be remarked that in addition to those patients being now discussed, following other operative experiences in this field, that state of affairs has constantly prevailed. The failure, in my personal experience, of jaundiced patients to have a strong tendency to postoperative bleeding is in distinct contrast to the experience of Walters, Judd, Lahey and others. It may be that

RESULTS OF CHOLECYSTECTOMY

patients living far South, under different climatic and dietetic conditions from the northern and eastern clinics, lack the hemorrhagic diathesis Maes¹⁶ says that bleeding has been rare in his experience, and that he is "not particularly fearful of deaths in patients who are jaundiced and in whom surgery of the biliary tract is indicated" During the past ten years Barksdale has had no incidence of postoperative hemorrhage On the contrary, McGehee, Sanders, Mason,¹⁷ Haggard¹⁸ and Elkin have not had so fortunate an experience

TABLE III

RESULTS IN PATIENTS SURVIVING OPERATION	
Cured	66 0%
Improved	27 7%
Unimproved	6 3%
Allergy—Patients positive (20)	
Cured	50 0%
Improved	40 0%
Unimproved	5 0%
Died	5 0%
Patients negative (80)	
Cured	65 0%
Improved	22 5%
Unimproved	6 25%
Died	6 25%
Results—Patients having stones in gallbladder or ducts or both (35)	
Died	11 0%
Cured	83 0%
Improved	6 0%
Unimproved	
Patients in noncalculous groups (65)	
Died	3 0%
Cured	51 0%
Improved	37 0%
Unimproved	9 0%
Patients having duct calculi (15)	
Died	13 32%
Survivors	
Cured	93 0%
Improved	7 0%
Deaths subsequent to surgery—cause and time death postoperative	
Cerebral apoplexy	2 years
Cerebral apoplexy	5 years
Stab wound heart	4 years
Acute pancreatitis	4 years
Result of accident	6 years
Acute intestinal obstruction	2 years
Hepatic failure	2 years
Incidence wound evisceration—none	
Incidence postoperative hernia—2 per cent	

The question of allergy is an interesting one (Table III). Of the patients reported, 20 per cent gave a definitely positive allergic history, and of these, 50 per cent were cured, and 40 per cent were improved following operation (that is, insofar as their dyspeptic symptoms were concerned), and occasionally their allergic manifestations were relieved. This is in contrast to 65 per cent of the nonallergics who were cured, and 22.5 per cent of the nonallergics who were improved following cholecystectomy. It is worthy of comment, also, that in the presence of allergic manifestations, cholecystograms may not be of the diagnostic help that they are in the nonallergic group. It has been estimated by Lahey that the diagnostic accuracy of cholecystography in gallstones is 98 per cent. Singleton believes, further, that the function of the gallbladder can better be determined by cholecystograms than it can be judged by inspection at the time of surgery. There is little doubt that a fairly definite number of poor results occur because the patient is subjected to surgery under an erroneous diagnosis, an individual whose symptoms are the result of an allergic reaction, or disease elsewhere, being thought to have cholecystitis. The vast majority of individuals of middle age will show microscopically, changes in the gallbladder, but these findings are of little significance and do not warrant surgery. Such persons, suffering only physiologic disturbances, or having only mild pathologic changes, are not suitable candidates for surgery, and will not obtain a satisfactory result following its performance. These are the individuals who go from clinic to clinic, only to, eventually, become surgical derelicts.

Of those who had stones, 83.52 per cent were cured, 50.49 per cent, who had only cholecystitis, were cured. There were 92.28 per cent who had, in addition, common duct stones, who survived operation, and were cured. The operative mortality in the group having stones in, or stricture of, the duct was 13 per cent. In each instance in which common duct stones were found, the duct was drained for a variable period of time, generally by the use of a T-tube. Since the advent of cholangiography, all have had the tube left in place until roentgenograms indicated a normal restoration of the duct. In one instance a stone, inadvertently left behind, was successfully dealt with by the injection of ether through the common duct tube, following the suggestion of Pribram and of Walters.

Of the patients reported, 16 per cent were subjected to exploration of the common duct, and 15 per cent were found to have duct stones. In the experience of Walters,¹⁹ common duct stones were found in 109 instances of 812 operations performed at the Mayo Clinic in 1936 (12.19 per cent). Lahey¹⁵ reports that, in 1935, in his Clinic, the common duct was explored in 44 per cent of the cases, and stones were found in 18 per cent of the patients subjected to surgery. Walters believes that "the possibility of stones in the common bile duct being overlooked could be reduced to an absolute minimum if the common duct were always exposed as a part of the operation of cholecystectomy." Unquestionably, the dictum of the late Sir Berkeley Moynihan²⁰ that the duct should be explored only when stones were felt must be abandoned. The indications for exploration of the duct are reasonably

plain, and if these indications are faithfully followed, it is highly unlikely that damage will follow failure to routinely explore the duct. On the contrary, routine exploration of the duct will very definitely increase not only the morbidity but the mortality as well.

CONCLUSIONS

The immediate mortality is reasonably low and the percentage of successful end-results exceedingly high following skillfully performed procedures for actual cholecystic disease. The end-results are decidedly better in those patients operated upon for cholelithiasis than when extirpation of the gallbladder is performed for inflammation alone.

On the contrary, operations performed for mild or nonexistent gallbladder pathology, or for simple physiologic disturbances, will yield universally poor results.

Allergic individuals should be cautiously subjected to surgery, and then only provided extensive and definite symptom-producing disease of the gallbladder is present. Cholecystograms in this type of patient may be misleading.

Time, and the accumulation of a huge mass of statistics, continually confirm the criteria formerly, and frequently, laid down by Walters, Lahey, and others, regarding the indications for exploration of the common duct. Cholangiography is a definite aid in determining when to remove the tube from the common duct.

REFERENCES

- ¹ Crump. Quoted by Rehfus, Martin E. The Gallbladder Problem. *Rev Gastro-enterol*, 2, No. 3, 187, September, 1935.
- ² Mentzer. Quoted by Rehfus.¹
- ³ Hoffman. Quoted by Rehfus.¹
- ⁴ Macdonald, Dean. A Practical and Clinical Test for Liver Reserve. *Surg, Gynec and Obstet*, 69, 70-82, July, 1939.
- ⁵ Sanders, R. L. Personal communication.
- ⁶ McGehee, J. Lucius. Personal communication.
- ⁷ Elkin, Dan. Personal communication.
- ⁸ Barksdale, John W. Personal communication.
- ⁹ Boyd, Phillips L. The Postoperative Mortality of Cholecystitis. *New Eng Jour Med*, 218, No. 25, 1045-1050, June 23, 1938.
- ¹⁰ Kunath, Carl A. The Stoneless Gallbladder. *J A M A*, 109, 183-187, July 17, 1937.
- ¹¹ Finsterer, H. The Immediate and Permanent Results of Operative Therapy in Cholelithiasis. *Wien med Wchnschr*, 48, 966-971, 1935.
- ¹² Schittenhelm. Quoted by Finsterer.¹¹
- ¹³ Tallquist. Quoted by Finsterer.¹¹
- ¹⁴ Jaguttus. Quoted by Finsterer.¹¹
- ¹⁵ Lahey, Frank H. Stones in the Gallbladder and Bile Ducts. *Surg Clin North Amer*, 15, 1459, December, 1935.
- ¹⁶ Maes, Urban. Personal communication.
- ¹⁷ Mason, James M. Personal communication.
- ¹⁸ Haggard, W. D. Personal communication.
- ¹⁹ Walters, Waltman. Abnormal Function of the Common Bile Duct Resulting from Benign Conditions. *ANNALS OF SURGERY*, 106, No. 4, 726, October, 1937.
- ²⁰ Moynihan, Berkeley. *Abdominal Operations*. 4th Ed, W. B. Saunders & Co., Philadelphia, 1, 642, 1926.

THE SURGICAL MANAGEMENT OF STONE IN THE COMMON BILE DUCT^{*}

FOLLOW-UP STUDIES WITH SPECIAL REFERENCE TO GRADED DILATATION OF THE SPHINCTER OF ODDI

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IN 1935, we^{1 2} published a method of surgical procedure for exploration of the extrahepatic bile ducts. At this time, we reported some experimental work and some clinical data relating to the method. The chief theme of the communication was the adaptation of routine, gentle dilatation of the sphincter of Oddi in all cases of common duct exploration. Prior to 1930, we had accomplished this by the very satisfactory method described by Cheever,³ which was based on the use of stiff, woven Coude urethral catheters. The difficulties with these instruments were those of sterilization, their tendency to become brittle and rough, and their bulk. The advantages were that fluid could be injected into them to determine their course through the papilla into the duodenum.

In 1930, our attention was called to the long, olive-shaped, graduated metal bougies of Bakeš.⁴ These instruments are calibrated from 3 to 14 Mm in diameter. The handles are of malleable metal, so that they may be shaped according to the contour of the operative field, and are soft enough to eliminate the hazard of creating a false passage. Bakeš made claims that by the employment of these dilators to a size just smaller than the diameter of the common duct, one may produce a permanent elimination of the sphincteric action of its outlet. This, he believed, enhanced the passage of stones from the hepatic ducts that had either been overlooked at exploration or that might be formed there later. His claim to permanence of dilatation was based on two instances of greatly enlarged ducts, the outlets of which had been stretched to more than 1 cm in diameter. One patient subsequently died of gastric cancer, at autopsy the papilla admitted a 13 Mm sound with ease—the size to which the dilatation had been carried at operation. The other passed a 14 Mm stone nine days after dilating the papilla to 14 Mm. He, like all other surgeons who have felt that the papilla should be routinely instrumentated whenever there was indication for common duct exploration, realized that this was the surest way of providing adequate bile drain-

^{*} Read before the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

age into the duodenum, also, that the simple determination of the patency of the papilla will prove inadequate in a small percentage of cases

It naturally occurred to us that such a practice might be attended by some danger and for this reason we approached the whole problem with considerable caution. We wished to work out a routine method that was satisfactory in our hands and that could be carried out without additional risk. By such a method we hoped to reduce the number of secondary operations for overlooked stone or for stricture and spasm of the duct outlet. We felt that we could be reasonably sure that the introduction of an instrument into the duodenum through the papilla of Vater from the open common hepatic duct was not a dangerous practice. This premise was based on the long clinical experience of many surgeons as well as our own. Also, we believe that Cheever had satisfied any question regarding the gradual dilatation of the papilla up to the diameter equal to that of a size No. 20 French catheter, or approximately 7 Mm. We did feel that we should try to ascertain the effect of such trauma and particularly to determine if, on occasion, the dilatation might be carried further with safety. The dangers of immediate infection, reflux of duodenal contents, precipitation of acute pancreatitis, and the production of a false passage all occurred to us. Also the effect of the immediate hemorrhagic reaction that must take place. We expected that this would, in a large percentage of cases, produce a temporary reactionary edema and were cognizant of the possibility of late cicatricial contraction. The effect of a permanently destroyed sphincteric action on digestion and the possibility of such an outlet being conducive to a future ascending cholangitis was also considered.

With these possibilities in mind, we carried out a series of operations upon the biliary system of large dogs. We found it difficult to reproduce the method we had thought suited to the average human with a pathologic biliary system and indications for common duct exploration. The dog does not tolerate easily an external tube in the common duct as should invariably be used after exploration in man. Although possible to arrange such drainage in the animal, it was felt unjustifiable due to the restraining mechanism required. When the common duct was explored and sutured as carefully as possible with fine silk, we had a high mortality from bile peritonitis, a well-known clinical fact. It was possible to produce some moderately enlarged common ducts by a previous cholecystectomy. We were able to dilate a few papillae from an opening in the duct and have the animal survive any bile leakage without external drainage. We found it quite safe to perform this dilatation transduodenally, since the opening in the duodenum could be accurately closed. Inasmuch as most of our patients were having the dilatation carried out through an opening in the duct, we questioned any conclusions that might be drawn from experimental, transduodenal manipulations. On the whole we believed that the dog with his thin, variable ducts could not easily be used for reliable comparative data with the usual pathologic conditions.

met with in man, and for these reasons discontinued these experiments, proving only that hemorrhagic reaction of a mild degree occurred after dilatation, as would be expected, and that while the animals lived there was no indication of cicatricial constriction. These experiments have been more thoroughly and adequately repeated by Zollinger, Bianchi and Bailey^{5 6}. These investigators have drawn conclusions from their researches which we believe to be at some variance with our clinical experience. For this reason we wish to set forth in some detail the results obtained by the method in our hospital. It is of interest to know that 39 members of the visiting staff and 33 of the resident staff participated in these operations. The data include the patients

TABLE I

BILIARY TRACT OPERATIONS

M G H, Oct 1, 1930-Oct 1, 1935 (Previously Reported)

	No of Cases	No of Deaths	Mortality Percentage
Cholecystostomy	82	12	14.5
Cholecystectomy	751	22	2.9
Cholecystectomy with common duct exploration and dilatation of sphincter*	231	9	3.9
Cholecystectomy with common duct exploration and sphincter not dilated*	164	8	4.9
	395	17	4.4
Totals (5 years)	1,228	51	4.2

* Under the heading "Cholecystectomy with common duct exploration" are included several cases of secondary choledochostomy, the gallbladder having been removed at a previous operation.

M G H, Oct 1, 1935-Oct 1, 1939

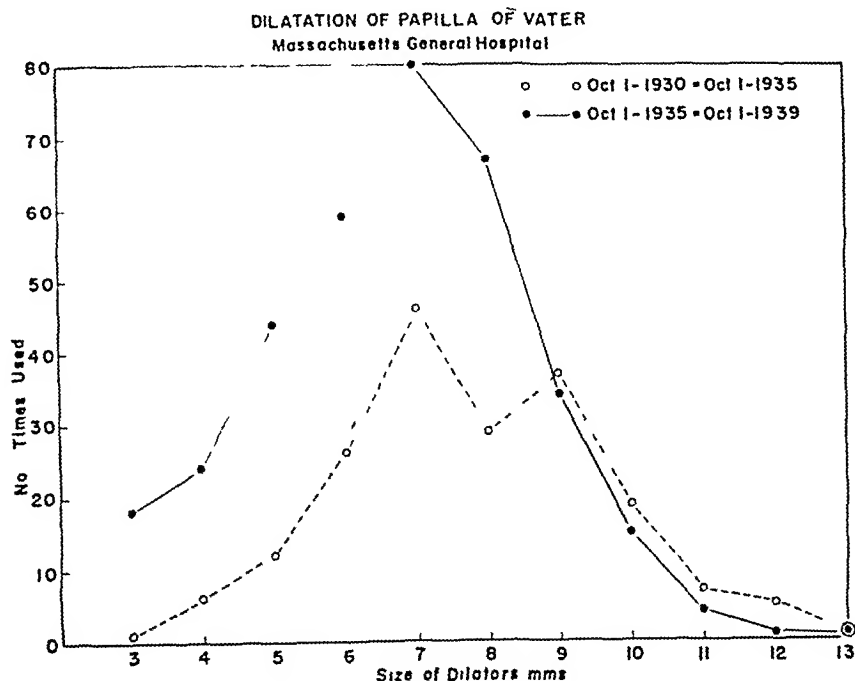
	No of Cases	No of Deaths	Mortality Percentage
Cholecystostomy	48	4	8.33
Cholecystectomy	432	7	1.62
Exploration of the common duct with dilatation of the papilla of Vater	330	13	3.93
Exploration of the common duct without dilatation of the papilla of Vater	50	3	6.00
	380	16	4.21
Totals (4 years)	860	27	3.25

M G H, Oct 1, 1930-Oct 1, 1939

	No of Cases	No of Deaths	Mortality Percentage
Cholecystostomy	130	16	12.30
Cholecystectomy	1,183	29	2.45
Exploration of the common duct with dilatation of the papilla of Vater	561	22	3.92
Exploration of the common duct without dilatation of the papilla of Vater	214	11	5.14
	775	33	4.25
Totals (9 years)	2,088	78	3.73

operated upon in the Baker Memorial and the Massachusetts General Hospitals

From October 1, 1930, to October 1, 1935, 1,228 patients in our hospital were operated upon for disease of the extrahepatic biliary system. Of these, 395 had exploration of the common bile duct, 231 had instrumentation of the papilla, with an average dilatation of 7 Mm, 164 had nothing more done than the removal of existing calculi and the determination that the papilla was patent. In the four-year period, from October 1, 1935, to October 1, 1939, 860 additional patients were subjected to operations upon the biliary tract. Of these, 380 had common duct exploration, in this group 330 had



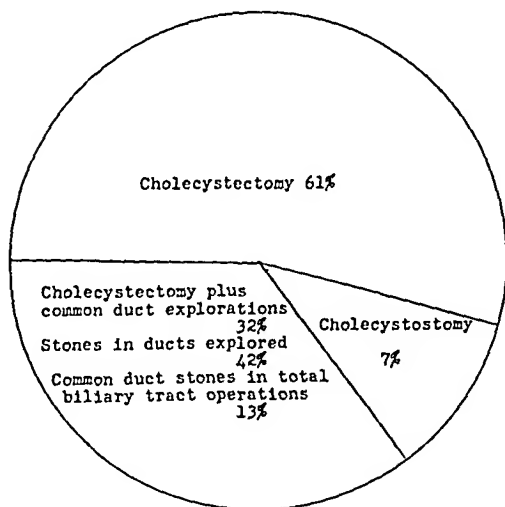
GRAPH 1—Showing the degree of dilatation and the frequency of its employment during the two periods October 1, 1930–October 1, 1935, and October 1, 1935–October 1, 1939

their papillae dilated while only 50 had a simple exploration. It is, therefore, apparent that more of our staff have become convinced of the safety and rationale of routine gentle, gradual dilatation of the duct outlet.

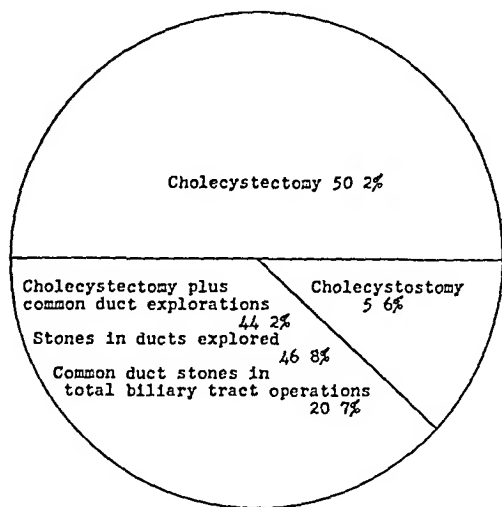
In Table I, it is seen that dilatation carried out in the manner that we have suggested does not increase the mortality. In fact, it would seem that this procedure was attended by less risk than exploration alone. This may not be true, since a patient doing poorly on the table may have caused the operator to omit instrumentation. On the other hand, in a careful analysis of all complications, we are impressed with the greater number of infections, prolonged biliary drainage, and longer hospitalizations in those patients who had no dilatation of their papillae. It would seem that at least one of Bakes' claims may have been justified, *i e.*, dilatation enhances the flow of bile into the duodenum.

In Graph 1, we see that the amount of dilatation has varied greatly, obviously it has been dependent on the size of the duct and the size of the stones

found either in the gallbladder or the ducts. No attempt should ever be made to stretch the size of the duct itself, and we feel sure that this has not been done in our cases. It is unfortunate that the Bakeš dilators have too frequently been referred to as common duct dilators. The peak of the curve is definitely 7 Mm, from 6 to 8 Mm having been used on more than two-thirds of all the cases. In the smaller sizes one may well wonder whether any dilatation could have taken place since the normal papilla will admit the 3 Mm dilator with very little resistance. We do, however, encounter some papillae associated with small thickened ducts that do not permit the use of the medium sized dilators. On the other hand, we have some very large ducts with very large stones present. One can with ease determine the size of the hepatic ducts and assume that a stone may be tucked away within the ducts above the portal fissure. It is in such a dilated biliary tree that one is justified



GRAPH 2—Showing the nature and percentage of biliary tract operations performed at the Massachusetts General Hospital, during the period October 1, 1930–October 1, 1935



GRAPH 3—Showing the nature and percentage of biliary tract operations performed at the Massachusetts General Hospital, during the period October 1, 1935–October 1, 1939

in gradually stretching the papilla to the size of the hepatic duct. This occasionally requires the use of the larger sized dilators.

There has been a gradual increase in the percentage of ducts explored and stones found as shown in the comparative Graphs 2 and 3. The incidence of stones found in all biliary tract operations might be indicative of many overlooked stones in the former series and should have resulted in a very large number of patients returning for further surgery. As a matter of fact, the proportional increase is far greater than the incidence of unrelieved patients. We are inclined to attribute this discrepancy to a better system of immediate postoperative notes. We have not included cases that have been recorded as having had "mud" or "detritus" in the ducts with those having had stones. Also, there may be some variation in the type of patient coming to a general hospital clinic in comparison to a selected group. For instance, in our own personal series of 266 biliary tract operations during this period, 159, or 59.7

per cent, had duct explorations, in whom stones were found in 98 instances. This represents 61.6 per cent of the ducts explored, or 36.8 per cent of all cases operated upon for biliary tract disease.

The data in Table I indicate a more radical tendency as regards cholecystectomy rather than cholecystostomy, but we still feel that the latter operation is justifiable under certain circumstances, particularly in the aged and very ill patient. One must also admit that exploration of the ducts superimposed on cholecystectomy adds to the risk. It must be borne in mind, however, that the indications for common duct exploration are clear-cut and definite, also that these patients, on the whole, represent poorer risks on the basis of their pathology alone.

TABLE II
CAUSES OF DEATH IN COMMON DUCT EXPLORATION
M G H, Oct 1, 1930-Oct 1, 1939

	561 Dilated Cases	214 Nondilated Cases
Pneumonia	5	1
General peritonitis	3	3
Bile peritonitis	4	0
Hemorrhage	2	3
Bilateral pulmonary atelectasis*	3	0
Cardiac failure	3	1
Pulmonary emboli	1	2
Acute pancreatitis	1	0
Subdiaphragmatic abscess	0	1
	—	—
Totals	22	11

* One death on operating table.

A careful comparative analysis of the complications following exploration of the ducts with and without dilatation of the papilla of Vater has been made. The fatal postoperative complications are summarized in Table II. There is not enough difference in the mortality percentage in the two groups to warrant argument, although there is a constant increase of over 1 per cent in those patients who did not have instrumentation of the papilla. It would seem that pulmonary complications were more frequent in those patients who had dilators passed through the duct outlet. This may be a coincidence but one must accept the fact that the added time consumed may be of significance. Also, there were four deaths from bile peritonitis in the group who had dilatation and none in those not dilated. This brings up points of detail of technic which are important even if it bears no real relationship to instrumentation of the papilla. These will be more completely discussed in a subsequent publication. Briefly, it means that the duct should never be sutured without adequate drainage to the outside. We believe that this should be accomplished by means of a tube sutured into the duct as well as drains placed in the most dependent area of this region. It is of utmost importance to be sure that the tube is draining bile before the abdomen is closed. Also, if there

is profuse bile drainage into the dressing or signs of bile peritonitis and little or no bile is coming through the tube, then the patient should be reoperated upon and the mechanical faults of the drainage corrected. The earlier this is recognized and remedied, the better the convalescence. It is pleasing to note that deaths from hemorrhage in jaundiced patients will probably not be recorded in the future, since the dramatic advent of vitamin K has eliminated this hazard.

TABLE III

POSTOPERATIVE HOSPITAL DAYS (NONFATAL COMPLICATIONS)

Papilla	561 Dilated	214 Not Dilated
Discharged by the eighteenth day	402, or 71.6%	109, or 50.9%
Remained in the hospital longer than 20 days	90	60
Private cases with no surgical reason for delay	29	6

TABLE IV

REASON FOR PROLONGED HOSPITALIZATION

Papilla	Dilated	Not Dilated
Wound sepsis	29	18
Pulmonary	9	2
Prolonged biliary drainage	4	27
Bile peritonitis	4	1
Study for other diseases	4	
Dehiscence	3	1
Miscellaneous	8	5
Totals	61	54
Per cent of total	10.9	25.7

The nonfatal complications are recorded in Tables III and IV. Based on the number of postoperative hospital days necessary, it is obvious that the patients who have instrumentation of the papilla have a shorter convalescence. The most striking difference is the greater number of patients who have prolonged drainage of bile to the outside in the nondilated group. This would indicate that instrumentation enhanced the flow of bile through the papilla. Table V further confirms this evidence.

TABLE V

PROLONGED BILIARY DRAINAGE

Papilla	561 Dilated	214 Not Dilated
Prolonged drainage	4	27
Discharged draining bile	4	18
Reoperated cases	4	8

It is apparent that many of the theoretic objections to instrumentation of the papilla have not been substantiated, also that some of the complications most feared have occurred rarely if at all. There has been no death or serious illness from acute ascending infection in our group, although two cases of gas bacillus infection were reported by Lahey.⁷ There has been only one case of

duodenal reflux and this occurred early in the series, clearing up spontaneously in 21 days. This, we believe, may have been due to the only false passage recorded but we cannot be sure of the exact chain of circumstances.

Duodenal reflux occurred in two cases reported by Davis⁸ in an earlier series from our hospital. These patients had very large stones, long impacted in the papilla, and will be discussed later under destroyed sphincteric action. One case developed acute pancreatitis, with fatal outcome. Since many of these instrumentations were undertaken through areas of thickening in the head of the pancreas, it is surprising that more of these did not develop a fulminating, acute flare of inflammation.

In the complications that come after the immediate convalescence is passed, we are equally surprised that most of our dreaded sequelae have failed to develop. The possibility of the effects of destroyed sphincteric action has been stressed. It is obvious from our experimental data, as well as those of others, that the sphincter is not destroyed when dilatation is carried to or just under the size of the average duct. Also, it must be borne in mind that the peak of dilatation has been within physiologic limits in the majority of our patients. There have been, however, enough individuals with very large ducts, having the papilla dilated to 8 Mm. or more in our group, to warrant a guess that occasionally the sphincteric action may have been destroyed. There have also been some cases who had stones of 1 cm. or more in diameter impacted in the duct ampulla for some time prior to operation. In these patients, transduodenal exploration was sometimes necessary and the sphincter actually incised in order to remove the stone. In none of these cases was there any evidence that such a practice was conducive to cholangitis or serious digestive disturbances. It seems apparent that one could not destroy the sphincteric action of the papilla in the average case. We believe, however, that the loss of such action may not be too important to the health of the individual. The emphasis should be placed on the establishment of free bile drainage into the intestinal tract in the most normal manner consistent with the existing pathology. Since the duct runs obliquely through the duodenal wall in a longitudinal direction and there is a definite mucosal overhang to its outlet, there is obviously less danger of ascending infection in such a duct without a sphincter than there would be from the usual surgical anastomosis between the duct and the bowel.

TABLE VI

SECONDARY COMMON DUCT EXPLORATION

Papilla	561 Dilated	214 Not Dilated
Secondary operations	8, or 1.42%	11, or 5.14%
For stone	4, or 0.71%	9, or 4.21%
For cholangitis	1	0
For pancreatitis	1	1
For biliary cirrhosis	1	0
For cancer of the pancreas	1	0
For stricture	0	1

Late cicatricial contraction of the papilla following instrumentation has not occurred. We have been fortunate enough to reoperate on a few of these patients (Table VI). In four of these, the secondary operation was performed for stone, and in none was there any evidence of constriction of the previously dilated outlet. In two instances at least, the same size dilators that had been employed at the previous operations passed through the papilla. In the others, the papilla was instrumented with greater ease than at the original procedure. The reoperations for cholangitis and biliary cirrhosis were for preexisting conditions. This was probably true of the case of carcinoma of the pancreas. The one case of acute pancreatitis apparently had no bearing on the previous operation.

In the nine secondary operations for stone occurring in those patients who did not have the papilla dilated, it is fair to say that convalescence was good, and usually there was no return of symptoms after the stones were removed, even if the papilla was not instrumented at this second procedure.

There are some interesting follow-up data on patients who have had symptoms after operation but have not been reoperated upon. There were ten patients in the nondilated group who continued to have attacks of biliary colic after common duct exploration, with removal of stones. One of these became symptom-free after an attack of colic and jaundice occurring four weeks after operation and has remained well for seven years. The other nine cases continued to have symptoms for as long as they were followed: four of them from one and one-half to four years, five from one to six months. Most of these were advised to have a second operation but either refused or went elsewhere to have it done. There was one patient who had instrumentation of the papilla with removal of stones from the ducts, who returned at the end of two months with the story of having had four severe attacks of biliary colic similar to the attacks he had had prior to operation. He reported at intervals of six months and three years that he had been symptom-free since his first postoperative visit. It is obvious to us all that patients may pass a stone from the common duct following cholecystectomy with or without common duct exploration. Unfortunately, a good many of the overlooked stones must be removed at a subsequent operation. It is our belief that many more stones will pass the carefully dilated papilla than the normal one. Our study of these records would seem to support such a viewpoint.

SUMMARY AND CONCLUSIONS

(1) Comparative data have been presented on groups of patients with biliary tract disease who have been subjected to common duct exploration—with and without instrumentation of the papilla of Vater.

(2) It appears that careful, gradual dilatation of the papilla to a size less than the diameter of the common bile duct is a safe procedure.

(3) There were more postoperative pulmonary complications in the group that had had dilatation of the papilla.

(4) Fatal bile peritonitis also occurred in four of those patients who had

dilatation, while none occurred in the nondilated group. We believe the technical difficulties of drainage accounting for these deaths have been corrected.

(5) There was a lower percentage of mortality in those patients who had dilatation of the papilla. This is not marked and we admit that it may not be significant.

(6) The nonfatal complications were greater in those patients who did not have instrumentation of their papillae. This was particularly evident as regards prolonged external bile drainage, increase in number of hospital days, and necessary secondary operations.

(7) Serious ascending infection, either late or early, did not follow instrumentation of the papilla of Vater in our cases.

(8) Duodenal reflux occurred in only one instrumented patient and this cleared up spontaneously.

(9) Late cicatricial constriction of the dilated papilla has not occurred.

(10) We doubt the permanence of the dilatation in the average case. In very large ducts with dilatation carried to 1 cm. the sphincteric action may be lost. Under these circumstances, it does not seem to have interfered with the health of the patient.

REFERENCES

- ¹ Allen, A. W., and Wallace, R. H. Technique of Operation on the Common Bile Duct. *Am Jour Surg*, **28**, 533-561, 1935.
- ² Allen, A. W. The Diagnosis and Treatment of Stones in the Common Bile Duct. *Surg, Gynec and Obstet*, **62**, 347-357, 1936.
- ³ Cheever, David. Instrumental Dilatation of the Papilla of Vater and the Dislodgment of Calculi by Retrograde Irrigation—A Contribution to the Surgery of the Bile Passages. *Arch Surg*, **18**, 1069-1077, 1929.
- ⁴ Bakeš, J. On the Drainage-Less Surgery of the Bile Passages and on the Methodical Dilatation of the Papilla. *Zentralbl f Chir*, **55**, No. 30, 1858-1868, 1928.
- ⁵ Zollinger, R., Branch, C., and Bailey, O. Instrumental Dilatation of the Papilla of Vater. *Surg, Gynec and Obstet*, **66**, 100-104, 1938.
- ⁶ Branch, C., Bailey, O., and Zollinger, R. Consequences of Instrumental Dilatation of the Papilla of Vater. *Arch Surg*, **38**, 358-371, 1939.
- ⁷ Lahey, Frank H. Stones in the Common and Hepatic Ducts. *New England Jour Med*, **213**, 1275, December 26, 1935.
- ⁸ Davis, L. Reflux of Duodenal Contents Through the Bile Duct. *New England Jour Med*, **200**, 313, February, 1929.

SOLITARY CYSTS OF THE SPLEEN *

FOY ROBERSON, M D

DURHAM, N C

THE SUBJECT of this communication has a twofold purpose. First, to put on record before this Society two more cases of this comparatively rare condition, also, to call your attention to some of the rapidly changing thought in record to surgery of the spleen. The two cases herein reported were seen during 1937, the first was of the hemorrhagic type, and was operated upon by one of my colleagues, and will not be reported in detail. The second was operated upon by myself, and was of the serous or lymphatic type, being a definite, true, solitary cyst of the spleen. This case will be reviewed somewhat in detail.

Solitary cysts of the spleen should be classed as (1) Hydatid (2) Hemorrhagic (3) Serous or lymphatic. The cause of hydatid cyst is definitely known and the diagnosis can be made and appropriate treatment instituted.

Hemorrhagic cyst of the spleen is due to hemorrhage either under the capsule or into its substance. The cause of the hemorrhage may be traumatic or spontaneous. The diagnosis and treatment in this type do not usually present difficulties, although the cause of the hemorrhage may not always be clear. The contents of such cysts are bloody and the lining wall in the hemorrhagic type is made up of fibrous tissue and has no epithelial lining.

The third type of solitary cyst, serous or lymphatic, is also a rather rare condition. Its contents are serous or lymphatic, which coagulate upon standing, and the wall of the cyst has an epithelial lining. To give you an idea of the rarity of this condition the Mayo Clinic, over a period of 36 years, from 1904 to 1934, reported 646 splenectomies, only two of which were recorded as cysts of the hemorrhagic type, and none of the lymphatic type.

Howald,¹ in 1926, was able to find records of 73 in the literature, of the type concerned in this group. Fowler² has ascribed the serous or lymphatic cyst to trauma, peritoneal inclusion, dilatation of the splenic sinuses, and degeneration due to arterial insufficiency in infarcts or tumors. So far as I know, there is no classic train of signs and symptoms by which these cysts may be diagnosed. They may, by accident, be found by the patient feeling an enlargement in the upper left quadrant of the abdomen, or in the course of a routine diagnostic survey of the patient. A study of cases reported will reveal the fact that the signs and symptoms usually differ quite widely in individual cases and are often misleading as will be seen in my own, as herein reported. There is no typical blood picture.

Case Report—My patient had been variously diagnosed as appendicitis, visceroptosis, and renal infection. There were good reasons for each of these diagnoses. She was operated upon, January 12, 1938. However, she had been under the treatment of two or

* Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

three other physicians as far back as 1935. There was nothing significant in the family or the patient's history. She was a very intelligent young woman, age 23, a proof-reader by profession. Her story was that she gradually became weak, lost weight, had indigestion accompanied by nausea, acne developed over the face, she developed low back pain and also symptoms suggestive of appendicitis, and became moderately anemic, apparently of a secondary type. Her ailments became so exaggerated that she found herself losing time from her work, necessitating rather frequent vacations. She would improve during rest periods but would relapse into the same condition after returning to work. It was during the course of a general diagnostic survey that the tumor was felt in upper left quadrant, and roentgenologic examination revealed an enlarged spleen, the stomach was pushed downward to the right, left kidney downward, and there was more or less general visceroptosis and urinary disturbances. The exact nature of the enlarged spleen, of course, could not be determined. However, it having followed shortly after the other case referred to, namely, that which proved to be a hemorrhagic cyst, we suspected a cyst of the spleen. Operation was not advised, however, until after the patient had been given a series of roentgen ray treatments, which did not afford relief, finally, operation was decided upon, at which a cystic spleen was revealed. A splenectomy was performed.

Pathologic Examination—Gross Path No 121-86, Dr Roberson. The specimen is a spleen, considerably enlarged, roughly measuring 9x11x17 cm, and weighing 1,350 Gm. The upper and lower poles show grossly normal splenic tissue, but the greater part (central) is occupied by a large cyst, containing clear, straw-colored liquid, which coagulated on the standing. The lining of the cyst is white and shows numerous trabeculae, flattened against it. Except at the poles, the wall of the cyst is rather thin, averaging 2 to 4 Mm in thickness. The fluid from the cyst contains no parasites, and cultures for bacteria are negative. *Microscopic*. Sections from the upper and lower poles show splenic tissue of the usual structure. The wall of the cyst contains much dense, hyaline fibrous tissue and is lined by a single layer of flat cells, which are slightly swollen in places. *Pathologic Diagnosis*. Dr Thomas H. Byrnes. Cyst of spleen, nonparasitic.

Postoperative and Subsequent Course—The patient stood the operation satisfactorily, being quite frail and anemic, she was given a blood transfusion following the operation. She made a good operative recovery and eventually returned to her employment as a proofreader, however, she still found herself unable to continue at work, and the low back pain persisted. It was probably not connected with the splenic condition. Her general health improved but not as much as desired. She is now acting as an assistant in a dentist's office and is getting along fairly well. The acne on the face has practically disappeared, leaving some scarring, but she gives one the appearance of being older than she really is, she is now in her twenty-fifth year but her tissues are those of a person five or ten years older.

An interesting question is: What was the exciting cause of this condition which practically destroyed the spleen, and what effect upon the organism, as a whole, has the splenectomy had? In short, by removing the spleen we stopped the progress of the condition but we have not supplied what the loss of the spleen has entailed, which leads us to a brief discussion of the second idea as the purpose of this communication, namely, a discussion of recent developments in the knowledge and functions of the spleen.

Hanrahan and Vincent³ discuss this subject and make the following comment: "During the past decade much advance has been made in the knowledge of the spleen. It should no longer be said that the function of the spleen is unknown. The advance in anatomy and physiology, combined with much more exact hematologic diagnostic technic and information regarding the blood disorders, has led to considerable revision of our conclusions regarding

the indications for, and results of, splenectomy in those disorders." For instance, in the Mayo series of 646 splenectomies, a good many were performed for pernicious anemia and thrombopenic purpura hemorrhagica. The knowledge gained following the work of Whipple⁴ on the anemias in general, and the observations of Minot and Murphy on liver treatment in pernicious anemia, would probably in the light of present knowledge, eliminate many of these operations. The so-called splenic anemia group, which according to these workers should be classified as anemia with splenomegaly, also the group of conditions coming under the head of Banti's disease would probably show by modern hematologic diagnostic technic, and would no doubt be amenable to medical treatment without resort to splenectomy.

This leaves the question of what ultimate effect splenectomy has on the organism, as a whole, unanswered, but, as further study of the functions of the spleen is resorted to and more knowledge gained, the answer to this interesting question will no doubt be forthcoming sometime in the near future.

REFERENCES

- ¹ Howald, R. Frankfurter Ztschr f Path, Munchen, 33, 349, 1926
- ^{1a} Pohle, W. Cysts of the Spleen with Special Consideration of a Case of Large Cyst of the Spleen in a Paratyphoid. Deutsch Ztschr f Chir, 221, 211-222, 1929
- ² Fowler, R. H. Lewis' Practice of Surgery, 6, Chap 15, p 3. W. E. Prior Co., Hagerstown, Md, 1929
- ³ Hanrahan and Vincent. Lewis' Practice of Surgery, 6, Chap 15, p 1, W. F. Prior Co., Hagerstown, Md, 1929
- ⁴ Whipple, A. O., Reeves, R. J., and Cobb, C. C. Atypical Hemolytic Anemias with Splenomegaly in Children. Tr Am Surg Assn, 46, 60, 1928

DISCUSSION —DR CHARLES GORDON HEYD (New York, N. Y.) I would like to report a brief history of a New York surgeon who, 30 years ago, had his spleen removed for rupture during the course of typhoid fever. About every ten years this gentleman has had a complete check-up and, so far as his physicians have been able to determine, there has not been a single deviation from the normal. It may, therefore, be said that whatever function the spleen serves, an individual is capable of leading a normal life without it.

DR J. DEJ. PEMBERTON (Rochester, Minn.) I would like to have the statistics from the Mayo Clinic brought up to date. Since 1904, there have been approximately 800 cases in which splenectomy was performed in the Mayo Clinic, and of this number there were only four cases of cyst of the spleen, an incidence of 0.5 per cent. I agree with Doctor Roberson, therefore, that a solitary cyst of the spleen is a rare condition. In the four cases that we have observed, all the patients were young people, the ages ranging from seven to 30, three were females and one was a male. There was no history of associated trauma in any of the cases. One woman had recently given birth to a child. This is mentioned because childbirth has been considered by some as a possible etiologic factor.

DR FOY ROBERSON (Durham, N. C., in closing) Doctor Heyd's report of the doctor who had the spleen removed is, I think, in keeping with the usual course of events in adult life after splenectomy. One might compare the function of the spleen with that of the thyroid gland, or probably other glands of internal secretion. After the individual has reached full development the internal secretion is not needed as it is in the growing child, or the lost function may be taken up by some other glands of internal secretion.

THE DIAGNOSIS AND TREATMENT OF ACUTE PANCREATITIS*

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THE DIAGNOSIS of acute pancreatitis by ordinary clinical methods is notoriously difficult and unsatisfactory. Evidence of this from the University of Rochester Hospitals was obtained when the subject was reviewed for the State Medical Society,¹ in the spring of 1939.

Early in the year, before getting together our material, consultations were had with many surgical leaders regarding their impressions about this condition. Their experiences, with scarcely an exception, were practically identical with our own.

It became apparent that at least three different pathologic types of pancreatic inflammation should be considered in any report on the subject. The acute edematous type could be subdivided further into mild and relatively severe forms. The hemorrhagic, necrotic type gave a more gloomy outlook. The suppurative form or pancreatic abscess occupied an intermediate position. At the time of my study this differentiation of the types in our clinic was very sketchy. From the clinician's standpoint he was lucky even to have considered the possibility of pancreatitis, let alone the finer shades of varieties.

The clinical picture was a confusing one for the severe forms of the condition. The symptoms and signs alone could not serve to differentiate the severe type of pancreatic edema from the other varieties. Pain was present in 100 per cent of all forms. It was sudden, severe, agonizing, in most instances. Occasionally it radiated transversely across the epigastrium from right to left. Vomiting occurred in 75 per cent. It was not a reliable symptom because it failed to persist in some cases but became almost continuous in others. Jaundice was present in only one-third of our patients. The presence or absence of shock depended upon the time when the patient was first seen by the physician. About 20 per cent of these patients were very fat and over one-half of them were more obese than the average. The most important vital sign was the relative increase of the pulse rate compared to the temperature. Tenderness was the outstanding physical finding. It was present in all cases, spasm was noted in 50 per cent, distention in 38 per cent. The white blood count averaged 17,000—an important aid.

At this time, in our clinic none of the special tests for pancreatic dysfunc-

* Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

tion were being made. They were considered to be too unreliable to be of value. Consequently we had no data on blood or urinary diastase, blood lipase, or tryptic ferment studies. We did record an occasional high blood sugar, and an occasional glycosuria in these patients.

Cases of milder pancreatic disorder were seen and so diagnosed without benefit of special laboratory tests. Consequently, they were not included in the report because they lacked scientific verification.

The diagnosis of acute pancreatitis of some form could be postulated when an obese individual had a sudden severe epigastric pain. If this was accompanied by vomiting, shock, tenderness in the epigastrium verging to the left, absence of fever, a relatively rapid pulse and a high white blood count, it was quite likely to be correct. Increasing distention would tend to further substantiate the diagnosis, and tenderness in the left costovertebral angle would be of additional aid.

The diagnoses suggested by the many physicians who saw these patients were compared with those actually made as acute pancreatitis. On this basis, from symptoms and signs alone, the correct diagnosis was made in only 17 per cent. The most common errors were severe, acute biliary tract disease, ruptured ulcer, intestinal obstruction or mesenteric thrombosis, peritonitis, and coronary occlusion.

Following this poor showing of diagnostic acumen, we decided to make use of some special test for pancreatic dysfunction. The literature of the last ten years is full of references to various tests which are in use especially in foreign clinics.

In reviewing the tests for the measurement of pancreatic activity, we decided that the amylase test was the most constant and satisfactory. Consequently, we adopted Somogyi's² amylase method for use in our clinic. This test is carried out as follows. A starch solution containing 75 mg of starch and 250 mg of sodium chloride per 100 cc is used as a substrate. The testing solution is made up of a 0.002 N solution of aqueous iodine in 2 per cent potassium iodide. Four cubic centimeters of the starch solution are placed in an ordinary test tube and immersed in a water bath at 40° C. While this is warming up 0.5 cc portions of the iodine solution are added to several small (7 Mm) test tubes. One cubic centimeter of the serum or plasma to be tested is then added to, and mixed with, the warm starch solution and the time noted. At intervals of two to five minutes, 0.5 cc samples of the incubating mixture are withdrawn and added to one of the small test tubes containing the iodine solution. This is then viewed in transmitted light. As the hydrolysis of starch proceeds, the original blue color will change to deep purple, light purple and finally to the red-brown color of erythrodestrin. The end-point is the time at which a barely perceptible tint of purple can be seen in the red-brown solution. If the amylolytic activity of the blood is high, the first specimen of the incubating mixture may be past the end-point when tested. If this occurs, one must either test a similar new set-up at more fre-

ACUTE PANCREATITIS

quent intervals or use serum diluted with 0.5 per cent sodium chloride, the latter method being preferable. In practice, the test is easy to do, and with some experience in the colors one can estimate the speed of the reaction and fewer sample tests will have to be made.

K

The results are calculated from the formula $AA \text{ (or D)} = \frac{K}{T \times V}$ where

AA is the amylitic activity of the sample, K a constant usually about 1,600, T the time in minutes required to reach the end-point, and V the volume of serum used. Normal values range between 70 and 200.

The concept of amylitic activity expressed in this way is an outgrowth of the use of copper reduction methods in sugar determination. By these methods

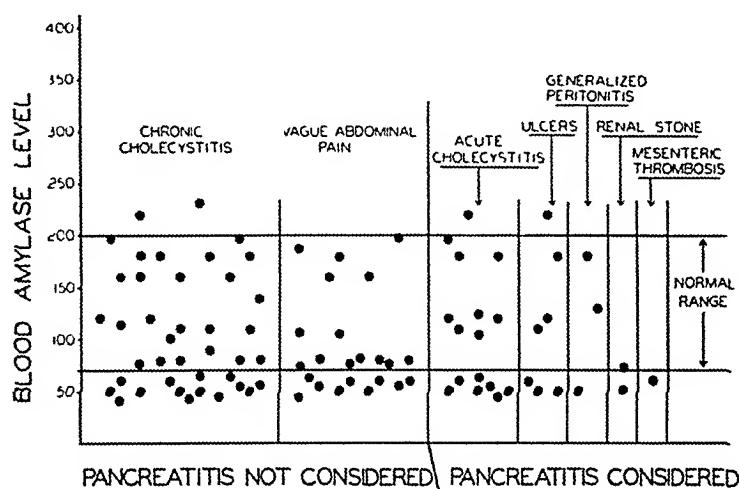


CHART 1—Showing the blood amylase determinations in various types of epigastric disease, undertaken in order to control its value

the sugar content of the serum was determined, after which another sample of serum is incubated with a starch solution under standard conditions and the "sugar" content of the starch serum mixture determined. The difference, then, represented the increased copper reduction resulting from the partial hydrolysis of starch and was expressed in terms of glucose. A value, for example, of 140 then means that, under standard conditions, 100 cc of the plasma would produce starch cleavage products having the same copper reduction as 140 mg of glucose. In Somogyi's method the glucose is not determined at all, but the results are expressed in terms of copper reduction assumed to be glucose formation. This apparent paradox is explained by the use of the constant K. In the correlation of a large number of determinations by copper reduction and the time methods, it was found that the value for K held under the conditions described. In other words, the same results will be obtained with the use of either the sugar reduction or the starch-iodine method. We have done a few determinations by both methods and find the correlation satisfactory.

Since June, 1939, we have used the amylase test in various types of cases where abdominal pain was a symptom. The distribution of values obtained is shown in Chart 1. In 40 cases of chronic cholecystitis, referred into the hospital for elective operation, two were slightly higher, and 14 were slightly lower, than normal. Of 23 patients with vague abdominal pain, none gave readings higher than normal. Of 29 cases in which pancreatitis was considered but not diagnosed, two were slightly higher and ten lower than normal. These 29 included cases of acute cholecystitis, ulcers, generalized peritonitis, renal stone and mesenteric thrombosis.

Of 12 cases showing significant elevations of blood amylase, nine came

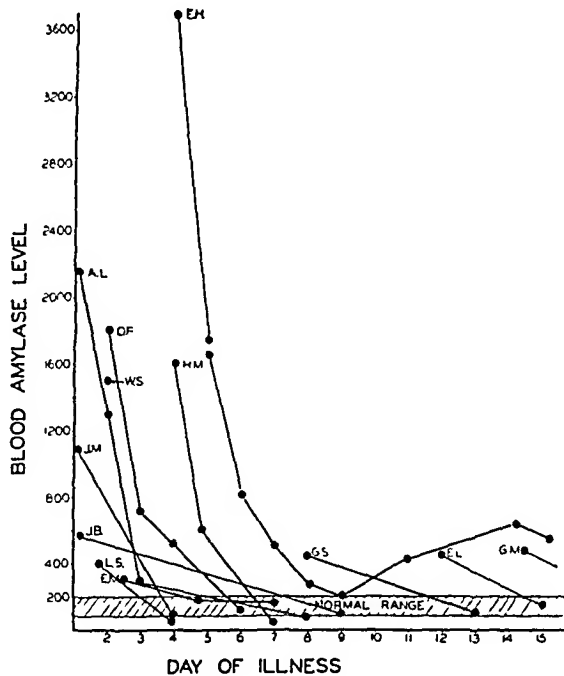


CHART 2—This records the cases in which the amylase test gave readings above normal. The individual cases, as indicated by initials, are discussed in the text.

to operation (Chart 2). Seven showed evidence of pancreatitis, and in those with higher amylase levels the edema was marked. Of the other two operative cases, L S (amylase 400) had a common duct stone with marked edema over the common duct with the pancreas normal to palpation. G M (amylase 430) was shown to have extensive carcinoma in the right upper quadrant with almost complete duodenal obstruction and the pancreas was not palpated. A L was operated upon with the preoperative diagnosis of acute cholecystitis. In J M operation was performed for suspected perforated ulcer. Both had edematous pancreases at operation. Preoperative blood amylase had not been estimated in either case because the diagnosis was not suspected. In both, the amylase level was found to be high after operation. In three cases with elevated amylase readings, not coming to surgery, we were able to fol-

low two O F presented the clinical picture of the disease and his readings gradually fell to normal in six days. He returned to the Emergency Department two weeks later with moderate recurrence of pain. At that time he showed an amylase determination of 270 but declined to remain for treatment. E M can be regarded as a questionable case. He was an alcoholic with diminished liver and kidney function with moderate upper abdominal pain. This cleared in about five days, during which time he was moderately ill. W S was discharged on the day following admission.

CASE REPORTS OF 12 PATIENTS SHOWING SIGNIFICANT ELEVATIONS OF BLOOD AMYLASE

Case 1—Hosp No 145426 E H, female, age 26, was admitted to the Rochester Municipal Hospital, May 13, 1939, complaining of epigastric pain. This began six days before admission with a transient attack which subsided. The pain returned four days before admission with radiation to both shoulders, nausea and vomiting. She had been unable to retain food for three days. On admission, the pain was localized in the epigastrium. There was no history of previous episodes. The patient had had nocturia of two times and some urgency but no burning for several years. Examination showed a temperature of 37.4° C, pulse 84, respirations 22. She appeared pale, acutely ill and dehydrated. Respiratory movements were limited. The breath sounds were slightly suppressed at the right base. The abdomen was scaphoid with localized epigastric tenderness and voluntary spasm with rebound pain throughout. The gallbladder was not palpable. Murphy's sign was equivocal. Left costovertebral angle tenderness was present. The white count was 18,800, and the urine showed a two plus acetone and many white cells in the catheterized specimen. The diagnosis rested between a low grade pancreatitis and chronic pyelitis. She was given parenteral fluids and mild sedation.

On the following day the epigastric pain was more severe and moderate distention was present. The temperature rose to 38.8° C and the pulse to 120. The blood amylase was 3,700, and the icteric index 18. Conservative treatment was continued and included a blood transfusion. On the third day, jaundice was evident but the patient felt better. The blood amylase was 800, and the icteric index 48. On the fourth day the icteric index rose to 83 while the amylase dropped to 80. The temperature, which had fallen, was again elevated.

Operation—The abdomen contained a large amount of clear yellow fluid. The head of the pancreas was swollen and indurated and small fat necroses were present. The gallbladder was distended and contained many stones. No common duct stone was palpable. The gallbladder was drained and a cigarette drain inserted into the lesser peritoneal cavity. There was bleeding from the wound which was controlled with transfusions and vitamin K. Her course was stormy. There was no drainage from the cholecystostomy tube. She was discharged from the hospital on the twenty-sixth post-operative day, and when last seen, four months after discharge, her only complaint was easy fatigability. *Postoperative Diagnosis* Acute edematous pancreatitis with fat necrosis, cholelithiasis.

Case 2—Hosp No 155656, H M, female, age 60, was admitted to the Strong Memorial Hospital, July 28, 1939, complaining of upper abdominal pain of four days' duration. This was of sudden onset, radiated to the back, doubled her up, and was followed by nausea, and vomiting without relief. The pain lessened but was constantly present until the time of admission. A history of intolerance to fatty foods was obtained. Examination showed a temperature 38° C, pulse 104, respirations 26, blood pressure 150/90. The patient appeared acutely ill. There was lower chest pain with coughing. The abdomen was slightly distended. There was tenderness in the epigastrium and right

upper quadrant, where slight spasm was present. The white blood count 6,800. There was bile in the urine. Icteric index 30. Blood amylase 1,600. The patient was considered to have an acute pancreatitis, probably on the basis of a common duct stone. Operation was advised but refused. Daily deep roentgenotherapy of 75 r was given for a period of six days. The amylase fell to 40. The patient improved but continued to have epigastric distress. Intravenous cholecystogram showed a small area of decreased density in the gallbladder and a dilated common duct. Gastro-intestinal series and barium enema were negative. Because of continued discomfort the patient consented to operation after 19 days.

Operation—The gallbladder contained sand and a single stone was removed. The head of the pancreas was the size of an orange, rubbery and lobulated. The common duct contained no stones. The postoperative course was febrile for three days after which improvement was slow and the patient was discharged on the nineteenth postoperative day. When last seen, six weeks after operation, her only complaint was slight tenderness at the site of the stab wound. *Postoperative Diagnosis* Subacute edematous pancreatitis, cholelithiasis.

Case 3—Hosp No 128221. A. L., male, age 53, was admitted to the Strong Memorial Hospital, May 24, 1939, complaining of severe upper abdominal pain, more marked on the right side. For two weeks he had had general malaise, upper abdominal soreness, anorexia and headache. The pain became quite severe the day of admission, and the patient felt faint. For the past two years he had had minor attacks of right upper quadrant soreness and nausea relieved by vomiting. In addition, he had two rather severe episodes less painful than the present one. Examination showed temperature 39.4° C, pulse 124, respirations 24. Blood pressure 120/80. The patient appeared acutely ill. General examination was negative. There was no jaundice. The abdomen showed marked tenderness and spasm in the right upper quadrant. The white blood count was 21,100. Blood amylase determination was not done. Diagnosis of acute cholecystitis was made and immediate operation performed.

Operation—The pancreas and surrounding retroperitoneal tissues were markedly edematous. The gallbladder was tense but smooth. Cholecystectomy was performed. Blood taken immediately after operation showed an amylatic activity of 2,160. The temperature gradually returned to normal on the fifth postoperative day. The patient was given small doses of deep roentgenotherapy on the second and third postoperative days. The blood amylase was 400 on the second postoperative day and 90 on the fourth postoperative day. The patient was discharged on the twenty-second postoperative day, and when seen one month after discharge, he had no complaints referable to the abdomen. *Postoperative Diagnosis* Acute edematous pancreatitis, cholecystitis.

Case 4—Hosp No 133361. J. M., male, age 71, was admitted to the Rochester Municipal Hospital, June 6, 1939, complaining of severe abdominal pain of three hours' duration. This came on suddenly and radiated across the abdomen but not to the back, shoulder or arm. The patient was soon doubled up and developed a cold sweat. There were no previous attacks of abdominal pain save for a severe attack of "cramps" 25 years ago. Examination showed a temperature of 36.5° C, pulse 60, respirations 18. Blood pressure 180/90. The patient appeared acutely ill. The skin was cold and moist. He was well preserved and there were no abnormalities of the cardiovascular system found. The abdomen showed tenderness and spasm in both upper quadrants. White blood count was 13,500, and an emergency electrocardiogram showed an interventricular conduction defect. He was considered to have either a perforating ulcer or a coronary occlusion. Three hours after admission the abdomen was board-like in both upper quadrants and operation was undertaken.

Operation—The abdomen contained much bile-stained fluid. The pancreas was indurated, swollen to about five times normal size, and showed tiny areas of recent hemor-

rhage Small areas of fat necrosis were present The gallbladder was distended No stones were palpable in the common duct Blood amylase immediately after operation was 1,100 The postoperative course was stormy and the temperature remained elevated for two weeks, during which time the patient was dangerously ill Deep roentgenotherapy of 50, 100 and 150 r was administered on the sixth, seventh and eighth postoperative days The wound became infected, partially digested and the drainage fluid was shown to have an amylitic activity of 4,000 With aluminum paste, frequent irrigations, and constant suction it finally healed in He was discharged from the hospital on the thirty-seventh postoperative day When last seen ten weeks after discharge he was feeling well and had gained some 20 pounds in weight *Postoperative Diagnosis* Early, acute hemorrhagic pancreatitis with fat necrosis

Case 5—Hosp No 157056 W S, female, age 37, was admitted to the Strong Memorial Hospital, September 13, 1939, complaining of severe abdominal pain This began 48 hours before admission It was most severe in the right upper quadrant and radiated to the back and right shoulder There had been constant nausea and repeated vomiting The pain was not relieved by a hypodermic of morphine given by her physician For the past three years she had had gallbladder attacks, once with jaundice, and she avoided fatty foods The pain had never been severe enough to require hospitalization before Examination showed a temperature of 37.6° C, pulse 84, respirations 22 The patient was in acute distress The skin showed no jaundice The abdomen showed marked right upper quadrant tenderness and spasm, but elsewhere was soft Murphy's sign was positive The white blood count was 6,800, and the blood amylase 1,500 On the following day the pain had largely subsided, but there was residual right upper quadrant tenderness The patient was discharged to her physician in Canada *Clinical Diagnosis* Acute edematous pancreatitis

Case 6—Hosp No 155800 O F, male, age 37, was admitted to the Rochester Municipal Hospital, August 1, 1939, complaining of epigastric pain of one day's duration This came on shortly after a hearty evening meal Vomiting was induced with slight relief He was able to sleep lightly On the morning of admission he ate a light breakfast and had little pain until three hours later Then the same pain returned of such severity that he stopped work He called his physician, who gave codeine and morphine, without relief Four days before admission he had a similar but transient attack with fever of 103° F All his symptoms subsided without treatment There was no history suggestive of gallbladder disease Five years ago he had had pain after meals with relief by an ulcer regimen for a short time On examination he was found to have a temperature of 40° C, pulse 96, respirations 20 Blood pressure 110/70 He was acutely ill The skin was not jaundiced The abdomen was scaphoid with epigastric tenderness and slight spasm No fluid wave could be demonstrated The white blood count was 17,800, icteric index 42, and blood amylase 1,800 The diagnosis rested between pancreatitis and a penetrating ulcer He was given little by mouth and daily deep roentgenotherapy of 75 r for three days After 24 hours the pain largely subsided The temperature returned to normal in 36 hours The blood amylase steadily fell to normal in five days On the fifth day, the pain was practically gone, and a barium meal showed a normal stomach and duodenum He insisted on discharge on the sixth day A gastrointestinal series, ten days later, showed slight irritation near the duodenal cap He returned two weeks after discharge with moderate epigastric pain The temperature was 38.4° C, white blood count 9,000, and amylase 270 There was tenderness deep in the epigastrium, without spasm He refused admission When last seen, three weeks after discharge, he was having no pain and wished to be returned to the care of his physician *Clinical Diagnosis* Acute edematous pancreatitis

Case 7—Hosp No 157,882 G S, female, age 69, was admitted to the hospital, complaining of epigastric pain and jaundice There had been repeated attacks of right upper

quadrant pain with subscapular radiation for three months. On the day before admission she began having constant, severe epigastric pain. Examination showed an acutely ill, jaundiced patient with a temperature of 40°C . There was diffuse epigastric tenderness more marked on the right side. The white blood count was 7,500, icteric index 30, and blood amylase 450. The diagnosis of chronic cholecystitis with cholelithiasis, common duct stone, and secondary pancreatitis was made. This was confirmed at operation four days later, at which time her general condition was improved and the initial prothrombin time of 55 seconds reduced to 20 seconds with vitamin K. The blood amylase on the day of operation was 100 and remained within normal limits during her stormy convalescence.

Case 8—Hosp No 57,189 J B, female, age 52, was admitted to the hospital, complaining of high abdominal pain which also involved the left chest, shoulder and arm. This began suddenly the morning of admission, and was associated with nausea, vomiting and diarrhea. A similar previous attack, 18 months before, had been diagnosed possible angina pectoris. Her only cardiac symptom was exertional dyspnea. A cholecystostomy had been performed 18 years ago at another hospital. At the time of admission, left upper quadrant and epigastric tenderness was present. The white blood count was 10,500, blood amylase 540, and nine days later 80. She was discharged after an 11 days' stay during which time an oral cholecystogram showed a nonfunctioning gallbladder.

Case 9—Hosp No 157,965 L S, female, age 54, was admitted to the hospital, complaining of right upper quadrant pain radiating to the subscapular region. This was her third and most severe attack. Continuous nausea was present. She was acutely ill with a temperature of 40°C , pulse 120. There was upper abdominal tenderness, more marked on the right side. White blood count 7,400, icteric index 48, and amylase 400. On the second day the amylase was 60. At operation, on the fifth day, the gallbladder was found filled with stones. There was marked edema over the common duct which contained a stone at the ampulla. The pancreas was normal to palpation. Her convalescence was uneventful.

Case 10—Hosp No 55,939 E L, female, age 59, was admitted to the hospital complaining of attacks of pain between the shoulder blades and on the right side of the abdomen. She gave a gallbladder history of one year's duration, with much pain during the two weeks preceding admission when jaundice became apparent. At the time of admission she was in no distress. The skin was slightly icteric. The liver edge was palpable. The icteric index was 30, white cells 10,300. On the following day she was suddenly seized with right costal and subscapular pain. The blood amylase was 400. Cholecystectomy was performed and several small pieces of gravel removed from the common duct. The head of the pancreas contained several rubbery nodules. Her convalescence was uneventful. Three days after operation the blood amylase was 150.

Case 11—Hosp No 157,530 G M, male, age 63, was admitted to the hospital, complaining of a biliary fistula of six months' duration. It was learned from his surgeon that carcinoma of the pancreas or bile ducts was suspected at the time of operation, but no mass was palpable. Previous to admission here, he had had a heavy feeling in the abdomen following meals but no vomiting. Examination showed obvious weight loss, and slight anemia, but no jaundice. There was a firm mass in the right upper quadrant. A gastro-intestinal series showed almost complete duodenal obstruction. The icteric index was 12, amylase 400, and one week later was 80. At operation a hard tumor was found in the duodenum, and the right upper quadrant was infiltrated with carcinoma. A gastro-enterostomy was performed. The patient died four days later from Type 19 pneumonia. Autopsy was refused.

Case 12—Hosp No 134,723 E M, male, age 33, was admitted to the hospital, complaining of upper abdominal pain beginning three days before admission and increas-

ing in severity. He was unable to retain food. He had been previously diagnosed as having cholecystitis, duodenal ulcer, renal stone, nephritis, and was a known alcoholic. The temperature was slightly elevated. The abdomen showed generalized tenderness without spasm and referred rebound pain to the epigastrium. White blood count 14,000 and 25,000, blood amylase 360, and icteric index 30. The urine contained albumin and a few white cells. The pain subsided. In three days the amylase was 100. He was shown to have a nonfunctioning gallbladder, dilated right ureter, and impaired liver and kidney function. He was discharged to be followed with conservative therapy.

It is claimed that the blood amylase test is given for only a transient period in the severe, hemorrhagic, necrotic forms of pancreatitis. We have not had sufficient experience to verify or deny this. If it be so it is unfortunate. The clinician certainly needs some assistance to arrive at the correct diagnosis in these individuals.

In a given case we make every effort to arrive at the diagnosis by a careful history and the ordinary methods of physical examination. Blood is taken for transfusion matching, for icteric index if indicated, and for the amylase test. If perforated ulcer is suspected, roentgenograms may demonstrate free air in the abdominal cavity. If obstruction is a possibility, a roentgenogram may show the offending loops. Coronary occlusion should give some changes in the blood pressure, or electrocardiograms should be helpful. If all these examinations reveal nothing significant, the amylase test may be helpful in arriving at the correct diagnosis. Abdominal paracentesis has been advocated³ and may be of assistance. The fluid recovered by aspiration may be opalescent, bloody, bile tinged, or serous. We suggest that an amylase test on this fluid may be diagnostic. In cases where drainage of the pancreas for pancreatitis has been performed in our clinic, we have found that the fluid gives high amylase test values.

Treatment—There is a wide difference of opinion as to the proper treatment for acute pancreatitis. Most surgeons agree, however, that acute pancreatic abscess should be drained. Drainage can be effected through the gastrocolic omentum, the gastrohepatic omentum, the foramen of Winslow or retroperitoneally in the lower flank.

The acute, fulminating, hemorrhagic, necrotic type has had a high mortality in the past from immediate operation. Some surgeons claim that they would not operate upon this form if they could be sure of their diagnosis. The fear of acute perforation of a viscus or strangulation of the bowel causes them to explore. The difficulty in diagnosis will undoubtedly remain and patients will continue to have explorations for these acute abdominal emergencies.

It would seem wise to take time to get these patients into the best possible condition before operation. Shock should be adequately treated and fluid balance restored. In the very ill patients, the most simple surgical treatment will be all that should be undertaken. If jaundice is present, drainage of the gallbladder or common duct may be employed to advantage. The pancreas should be disturbed as little as possible because it cannot be drained by split-

ting the capsule as formerly advocated. The organ is crisscrossed by connective tissue partitions so that it is made up of many separate chambers. Incision into it leads to hemorrhage, necrosis, and is damaging. The purpose of drainage is to establish sinuses and to wall-off the general peritoneal cavity from the extension of the secretions. The secretions are thus led out to the surface. Necrotic tissue can be extruded along these same drainage tracts. Large pieces of necrotic pancreatic tissue have been sequestered in this manner. The drains should be placed against the surface of the pancreas after the peritoneum over it has been greatly spread apart or incised.

Comparative statistics from several clinics show that there is a decided advantage in mortality when operation is delayed instead of being carried out immediately. Nevertheless, there is a mortality from delayed surgical treatment which must be expected in any series. Some of our patients have been too ill for operation and could not be rallied sufficiently to make it possible. There will also be a mortality from missed perforations or strangulations if a waiting policy is adopted in these severe abdominal catastrophes. This must not be discounted.

In the milder forms of acute pancreatitis as represented by the edematous variety, the amylase test is the most useful. The surgeon can be fairly sure of his diagnosis. He can watch these patients to advantage, being guided by the amylase readings. The surgeon will be on the alert to detect the edematous pancreatic tissue which he might easily miss without a signpost. There is a tendency for this form of pancreatitis to subside in most instances. After the subsidence of the attack exploration of the common duct with drainage for some weeks is usually all that is necessary to cure this condition.⁴

We have been interested in the analogy between acute parotitis and acute edematous pancreatitis. The amylase test gives elevated readings in each of these conditions. It seemed to us that if the acute parotitis had such a remarkable response to small roentgen ray treatments,⁵ the same might hold for the pancreas. Consequently, we have tried this treatment cautiously in several cases. The effect appears to be satisfactory. We have used 50 r and 100 r units measured in air through two portals for a total dosage of 250 r-450 r units. Dr. Andrew Dowdy has collaborated with us in this work. The effect is probably due to some chemical change in the body fluids. It is possible, however, that it may be due to temporary inhibition of the gland. Certainly, a small treatment over the salivary glands often causes diminution in secretion. This, in effect, puts the gland at rest. If so, it is good therapy for any infection. We believe that roentgenotherapy may shorten the attacks but we offer this only as a suggestion without adequate proof as yet.

REFERENCES

- ¹ Morton, J. J. Acute Pancreatitis. *New York State Jour. Med.*, 40, 255-263, 1940.
- ² Somogyi, M. Micromethods for the Estimation of Diastase. *Jour. Biol. Chem.*, 125, 399-414, 1938.

- ³ Peterson, L. Einige Worte ueber die Diagnose und Behandlung der Akuten Pankreas-Krankheiten Zentralbl f Chir, 61, 333-334, 1934
- ⁴ Cole, W. H. Treatment of Acute Pancreatitis, Collective Review Internat Abst Surg, 67, 31-38, 1938
- ⁵ Robinson, J. M., and Spence, J. Roentgen Therapy of Acute Postoperative Parotitis New England Jour Med, 215, 150-153, 1936

DISCUSSION —DR ROY D. McCLURE (Detroit, Mich.) It is interesting to note that the laboratory again has come to our aid in the early diagnosis of such an obscure condition as acute pancreatitis. As Doctor Morton pointed out, it is only by prompt, accurate diagnosis that one avoids the tragedy of overlooking perforations of the stomach or gallbladder, such as occurs when physical diagnosis alone is relied on. Doctor Morton did not mention discoloration of the subcutaneous tissue around the umbilicus or in the flank as a diagnostic sign in acute pancreatitis.

The value of the sign has recently been stressed by Dr Laurence S. Fallis, of our Surgical Staff at the Henry Ford Hospital, in a published report of three cases (Fallis, L. S. Cullen's Sign in Acute Pancreatitis ANNALS OF SURGERY, 106, 54-57, 1937). A positive sign is represented by ecchymotic areas surrounding the umbilicus or in the flanks. When the discoloration is in the periumbilical region, the condition is known as Cullen's sign, because he was the first to report it, though his observations were confined to cases of ruptured ectopic gestation. Grey-Turner, in England, has described ecchymosis of the flanks in acute pancreatitis, thus the sign is known as Grey-Turner's sign when it is seen in the flanks. The phenomenon is due to extraperitoneal extravasation of the products of pancreatic necrosis. The spread may be limited to the flanks or may continue forward until it meets obstruction from the round ligament of the liver, when the tendency is for the fluid to track downward and pool in the subumbilical space. We have noted the sign on four occasions, twice in the flank and twice at the umbilicus. A strong light is necessary for its recognition and it is likely the sign is often unrecognized because in one of our cases it was not until the patient's abdomen was exposed to the strong operating room light that the discoloration was noted.

The speaker then showed a colored slide on the screen, which demonstrated the discoloration in the flanks—a positive Grey-Turner sign. This patient had been ill for a week with an obscure upper abdominal condition, and it was not until this sign appeared that the diagnosis was evident.

DR IRVIN ABELL (Louisville, Ky.) Since the publication of my paper, which Doctor Morton quoted, we have had four additional cases of acute pancreatitis. The death rate still stands at nine, in a total now of 34. One clinical point in addition to those mentioned by the essayist which would possibly lead one to suspect the pancreas, is the history of gallbladder disease. This has been obtained in 28 of our 34 cases, 24 showing the presence of gallstones. Whether, as claimed by some, acute pancreatic edema is a clinical entity is open to dispute. My personal opinion is that edema, pancreatic necrosis, with or without hemorrhage, and pancreatic abscess are but parts of the same process, the diagnosis of each, as such, depending upon the time it is seen. In my paper I cited nine cases of pancreatic edema, all of which recovered, there were, however, three additional cases in which at the time of operation a diagnosis of pancreatic edema was made, all three died, one on the third, one on the sixth and one on the ninth day, autopsy, in all,

showing pancreatic necrosis. It is possible that the trauma of operation activated the process, but I am of the opinion that we were dealing with the first stage of what ultimately became a pancreatic necrosis. In ten cases, observed before 1925, an effort was made to drain the pancreas, going so far in two instances as to make incisions in the pancreas for this purpose. We had but one death in this group, and I think we were rather fortunate, in view of what we have since learned of the disease. Since 1925, such drainage as we have employed has been along the line laid out by the essayist in an effort to bring the ferment-laden fluids to the surface, rather than leave them in the abdomen.

I think all will agree that no operation upon the pancreas will lessen the tryptic digestion of the organ, and, hence, the less that is done to the pancreas itself, the better for the patient. We have had but two patients treated medically, in which the diagnosis was acute pancreatitis, one died and one recovered. No autopsy was permitted, consequently, I am unable to say whether the diagnosis was or was not correct. In patients subjected to operation, the diagnosis in 14 was acute pancreatitis, in 14, acute cholecystitis, and in the remaining six the diagnosis was divided between peptic ulcer and a high obstruction. The utilization of such a test as that mentioned by the essayist for amylase should produce a greater percentage of correct diagnoses, the amylase reaches an abnormal level in the blood within six to eight hours after the onset of an acute pancreatitis, and persists for from 60 to 80 hours at an abnormal level, following which time it gradually returns to normal. The blood lipase does not reach an abnormal level for three or four days after the onset of the acute condition, and persists for a longer period of time. The difficulties in reaching a correct diagnosis are such that I quite agree with the essayist in his statement that without exploration patients will be sacrificed who otherwise might be saved. There are certain indications which in the presence of an acute pancreatitis seem to me to demand operation, namely, an enlarged, palpable gallbladder, the presence of jaundice, the presence of fluid in the lesser omental cavity, and the detection of a mass at the site of the pancreas. I will go still further in my belief that drainage of the gallbladder is of benefit in the treatment of acute pancreatitis. Not infrequently, the gastrohepatic omentum is edematous and affords obstruction to the biliary tract, at times the enlargement of the pancreas offers the same difficulty, and drainage in such cases is helpful. Three patients in our series have previously recovered from an acute pancreatitis, and in all three, the diseased gallbladder may have been a factor in producing the second attack. Such an observation would indicate that following recovery from acute pancreatitis it is well at some subsequent date to correct any remaining pathology in the biliary tract.

DR GEORGE G FINNEY (Baltimore, Md.) At the Union Memorial Hospital, in Baltimore, we have had 21 cases that would come under the classification of acute pancreatitis. At most we have diagnosed two correctly from a clinical standpoint, and I am not sure about them. Of course, pancreatitis had been mentioned, but I do not think the diagnosis was certain enough to base a surgical procedure on it. There were nine deaths, making a mortality of 42.8 per cent. Treatment has been quite uniform in all cases, namely, immediate operation, except for the usual administration of fluids, and general supportive measures that were indicated first. In all cases, the gallbladder has been drained and also the region of the pancreas, but, so far as I could tell, in no case was pancreatic tissue incised. In one of my own

cases, the patient had an acute hemorrhagic pancreatitis. Beginning on his fifteenth day postoperatively he was afebrile, and was allowed out of bed on his twenty-third day. On the evening of the twenty-fifth day, he suddenly died, and autopsy revealed he had had a massive pulmonary embolus. It was also shown that fully four-fifths of his pancreas was completely necrotic, with a retroperitoneal abscess some five by seven inches in size, and it seemed almost incredible that the patient could have been afebrile and apparently clinically well. In the light of these findings, it seemed questionable whether he was really benefited by the usual procedure of operation. Any help we can get in the diagnosis of these cases along the lines suggested by Doctor Morton should be of great benefit.

DR JOHN J. MORTON (Rochester, N. Y., in closing) I want to thank the discussers for the very favorable reception of this paper. I know that it is a controversial subject and did not expect to get as much agreement as I have had. We hope we are going to be able to make our statistics compare favorably with others. The milder forms have not been included in my previous paper. The cases reported there were all severe. Some had fat necrosis of the pancreas and some died without any hemorrhage. We have postmortem examinations to prove these statements.

GRANULOSA CELL TUMOR OF THE OVARY ¹

REPORT OF A CASE

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AND

J. PEYTON BARNES, M.D.

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THE RARITY of these tumors and their very unusual life history seem sufficient justification to report a single case. Then endocrinology is the most interesting factor in the history, though probably not the most important. However, the thought that a tumor can arise from the ashes of a burned-out ovary, as it were, and build itself up from these ashes until it assumes some of the complicated functions of the original ovary is most intriguing.

This tumor was first described by Rokitsansky,² in 1855, and later by von Kahliden,³ in 1895, but much confusion has generally existed as to its origin and its possible malignant nature.

The name "Granulosa cell tumor of the ovary" was proposed by von Werdt,³ in 1914, and has been widely adopted. There are now about 300 or more granulosa cell tumors of the ovary on record, and there may be many unrecorded cases. Out of 400 solid tumors of the ovary examined at the Mayo Clinic,¹ 30 granulosa cell tumors were found.

The literature of this tumor has been written mainly in the last 15 years. In this country it has been contributed to largely by Novak, Dockerty and MacCarty, Telinde, Bland and Goldstein, Schattenberg and Harris, and many others. In 1937, Pratt¹ made a complete review of the literature up to that date, and reference is freely made here to his report. It was the intention of this paper "to correlate the clinical and histologic pictures of this tumor and undertake to show that it can, in most cases, be diagnosed before operation." This seems a very important objective, since uterine bleeding may result from other types of ovarian, as well as uterine disease. We are all "cancer minded," and any lesion, producing bleeding out of time, is of utmost interest.

No age, it seems, is exempt from the development of these tumors. Crossen and Crossen² point out that the "islands of embryonic sex cells or 'cell rests' may, at any age, begin to grow and function, causing symptoms of excessive ovarian activity. In children, the excess estrogen secreted by these tumors causes precocious puberty, the child maturing sexually at an early age. Menstruation may appear at two or three years of age, with secondary sex characteristics, such as enlargement of the breasts and the appearance of pubic hair.

¹ Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

The mental age and activities of the child are not in advance of its years. In cases in which the tumor does not begin until adult life, when the woman is already menstruating, the symptoms are frequently masked. There may be an increase in the amount of menstrual flow, but nothing else to indicate the presence of such a tumor. Occasionally, there are periods of amenorrhea interspersed with periods of menorrhagia. After the menopause, between 40 and 50 or 50 and 60 years, the tumor is likely to cause return of menstruation or prolongation of it, if the tumor becomes active before menstruation ceases entirely."

Novak⁴ has pointed out "that the cells of the granulosa cell tumor produce an excessive amount of follicular hormone, which gives rise to endometrial hyperplasia and uterine bleeding. When these tumors occur in elderly women, far past the menopause, there is brought about a sexual and genital rejuvenation due to the estrin produced by the neoplastic cells. The breasts and the external genitals hypertrophy, and pseudomenstruation sets in."

The diagnosis of this condition is not always easy. Good authorities believe that about 1 per cent of ovarian tumors associated with uterine bleeding in elderly women may be granulosa cell tumors of the ovary, provided neoplasia of the cervix and uterine body can be ruled out. It is also asserted that a tremendous amount of estrin is elaborated by these tumors in all age groups and can be demonstrated in the blood and urine, but, apparently, the estimation of estrogenic substances in the blood and urine has not often been done prior to operation.

In this connection, it is well to remember that a malignant tumor associated with granulosa cells might produce the same blood and urine test results. Also, during the active period of sexual life, it will be necessary to rule out ectopic pregnancy. A diagnostic curettage in an elderly woman, if it reveals cystic hyperplasia of the endometrium, indicates that granulosa cells are at least associated with any ovarian tumor present. It would seem that, in a woman who has long since passed the menopause, a flow of menstrual-like, dark, liquid blood might furnish the first clue to a diagnosis, especially if there should appear to be some periodicity to the flow.

In our case, menstruation ceased at the age of 40 and returned at 54, there being a period of complete amenorrhea of 14 years, its return was painless, surprising, and in the midst of the best health the woman had ever enjoyed. She stated that during the first postmenopausal flow, she experienced the same sensations she had at menstrual time in her early life, except that, being "cancer minded," she was terrifically frightened.

To our personal knowledge, this patient had had an ovarian tumor, thought to be a cyst of the right ovary, for more than 15 years. It was present for at least one year before the cessation of normal menstruation and for 15 years prior to the first postmenopausal flow. It was, therefore, present 15 years before it functioned as a granulosa cell tumor, or 15 years after it was originally discovered by one of us (F L B).

These tumors seem to be definitely malignant at times, while in other cases they seem to be clinically nonmalignant. In many instances, they seem to occupy the ovary with some other tumor, while in other cases the granulosa cell tumor fills the ovary entirely.

The typical granulosa cell tumor is described³ as "an encapsulated growth, the capsule being smooth, firm and fibrous. It is not adherent to the surrounding structures. The capsule may vary in thickness in different places. The tumor is not, as a rule, lobulated. The blood supply to the tumor is rich, and large vessels may be seen upon its surface. On section, the tumor is found to be of solid, soft consistency, or, more commonly, partly solid and partly cystic. The color of the tumor is often bright yellow, about the color of a ripe corpus luteum. Some tumors have a pinkish, fleshy color as described by Telinde." Our case conforms to this description in practically all details, and we are disposed to regard it, therefore, as being clinically non-malignant.

Case Report—M. H., white, female, age 54, married, has two children, ages 21 and 27, both living and well. She was married at the age of 22. She was operated upon between the births of the children. A uterine suspension was performed, the left ovary resected, and perineal and cervical repairs were made. At the birth of the second child, the lacerations were reproduced, but the cervix was never repaired. Menstruation began at the age of 12, continued to be normal after the operation, and ceased at the age of 40, but she did not have any of the nervous, mental, or vascular symptoms usually accompanying "the change" and had often "wondered why."

On August 11, 1938, a painless vaginal flow of blood appeared. This was accompanied by swelling of both breasts and nervousness, which were the symptoms she had experienced at menstrual time in early life, and she thought, also, that the blood "looked exactly like menstrual blood." On examination, elsewhere, two small ulcers were found on the borders of the old cervical laceration. At a subsequent examination, two small ulcers were found on the borders of the laceration, but they were not bleeding and appeared to be simple ulcers resulting, probably, from exploded cervical cysts. In the right ovarian region, there was found a round, elastic, freely movable tumor, thought to be a cyst. It was about the size of a baseball. The uterus was thought to be a little larger and a little softer than usual for one of her age. This ovarian tumor was known to have been present 15 years or more and was not thought to have any connection with the bleeding.

The ulcers, which were small, round, superficial, and not indurated, were widely excised with all scar tissue, and the cervix was repaired. The uterus was curetted as a precautionary measure.

The pathologic report of the cervical tissue and the uterine scrapings was negative for malignancy, and it was considered a "cystic degeneration of the cervix."

In about six weeks from the time of this operation, a painless, bloody uterine flow again came on. This flow again resembled menstrual blood and was accompanied by such symptoms as she had experienced in early menstrual life. An examination now revealed that the cervix was soundly healed, and a slight, painless menstrual-like flow was exuding from the cervical canal. It was now thought that the curette had missed some pathologic lesion in the uterus, or that the ovarian tumor was the cause of the bleeding, and the complete removal of the uterus and adnexa was undertaken.

At operation, the uterus was found to be a little larger and a little softer than we

GRANULOSA CELL TUMOR OF OVARY

would have expected and was not atrophic. On the fundus was a small subserous fibroid. The left ovary had been removed at former operation. The right ovary was about the size of a baseball, was elastic, freely movable, showed no evidence of adhesions, was completely encapsulated, showed a uniform, bright, pinkish-yellow color through the capsule, and was suspended by a short, flat, divided pedicle from the broad ligament.

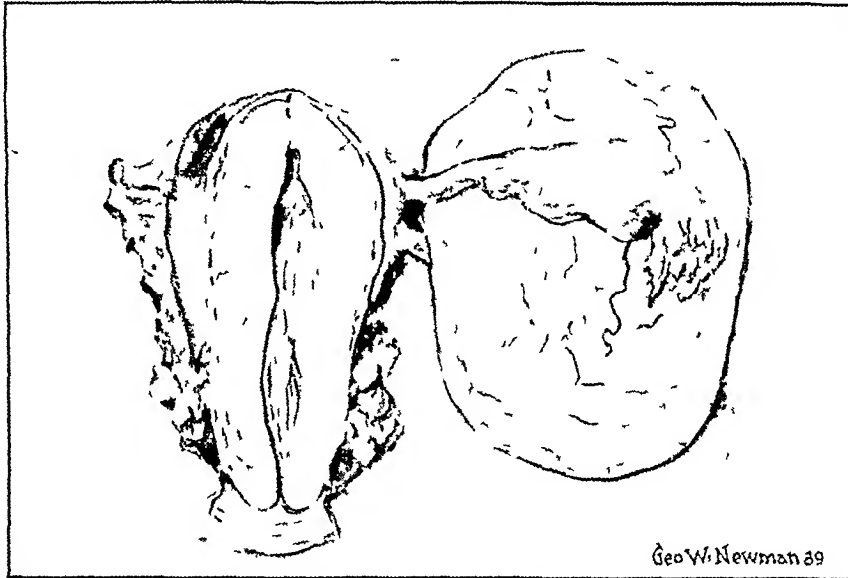


FIG 1—Uterus, tube, and ovarian tumor. Note smooth exterior with prominent vessels. The uterus is larger than normal postmenopausal organ, with abnormally thick walls and endometrium.

Pathologic Examination—Gross. Dr. A. H. Braden: "The ovary measures 6x7x6 cm and is well encapsulated. There are large vessels coursing over its surface. The tube is separated from it with difficulty (Fig. 1). The tumor is elastic, and, upon section, is a lemon-yellow color. The cut-section has some evidence of lobulation and a tendency to bulge (Fig. 2).

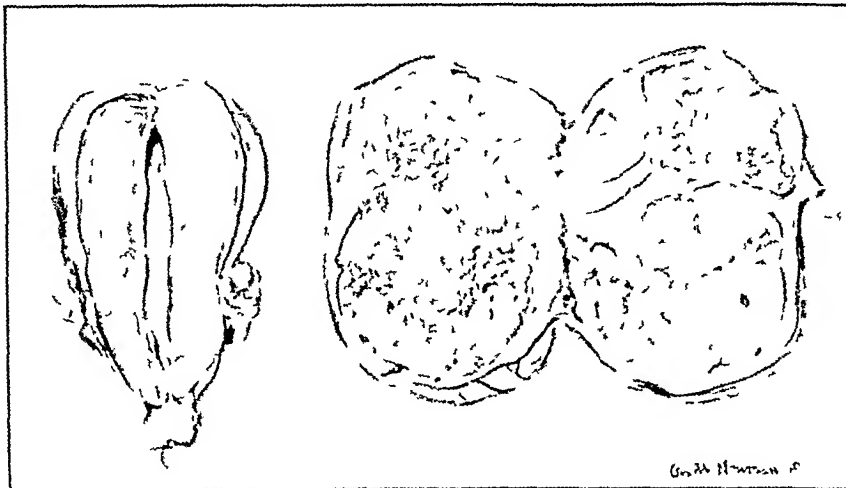


FIG 2—Uterus and ovarian tumor in gross section. Note smooth, thick, fibrous tumor capsule and lobulated cut surface.

"Microscopically, sections of the ovary show solid alveoli surrounded by a basement membrane. The cells have characteristic appearance. The cytoplasm is granular, and the cells have a somewhat spindle appearance (Fig. 3). This tumor is regarded as of low malignancy.

"The uterus measures 8x6x5 cm. The wall is thick and fibrous and the endometrium is more or less atrophic" (The uterus had been thoroughly curetted six weeks before.)

The endometrium showed gland acini to be rather scant and with some irregularity as to size and shape. The endometrium did not show hyperplasia, but the gland acini did show evidence of follicular hormone activity (Fig 4).

Pathologic Diagnosis—Folliculoma, or granulosa cell tumor

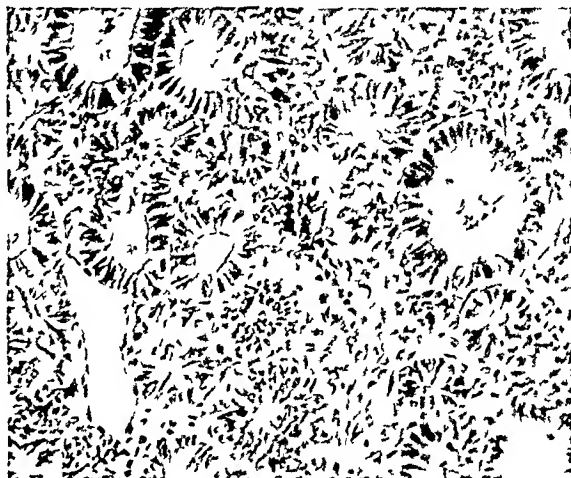


FIG 3—Photomicrograph of the ovarian tumor showing the granulosa type cells arranged in places to form small cysts

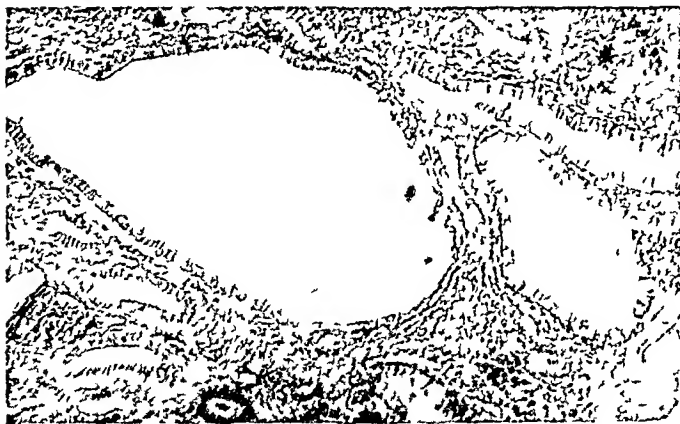


FIG 4—Photomicrograph of the endometrium. Note cystic changes in glands which are lined with ciliated columnar epithelium, the picture indicating follicular hormone stimulation

COMMENT—A typical granulosa cell tumor of the right ovary is presented, wherein the right ovary had been known to be the site of a tumor for at least one year prior to the cessation of normal menstruation and for at least 14 years, through a period of complete amenorrhea, prior to the postmenopausal bleeding.

The uterus was slightly enlarged and slightly soft and was not atrophic. The endometrium presented the, so-called, Swiss cheese appearance.

After the removal of the tumor she suffered the usual climacteric symptoms—occasional headache, nervousness, hot flashes and frequent perspiration.

An additional instance of this pathologic condition is herewith presented, through the courtesy of Dr A O Singleton, of Galveston, Texas

Case Report—Dr A O Singleton G W K, white, female, age 51, widow, mother of two children ages 16 and 18, both of whom are living and well, was admitted to the hospital because of postmenopausal bleeding in June, 1939. The menstrual history obtained at that time was that menstruation began at the age of 11 with 28-day intervals and of four to six days' duration. It was regular up to the age of 45. Then it became very irregular as to time and duration, until there was a complete amenorrhea lasting two years. It then returned and was again very irregular until it became almost continuous, when she was sent to the hospital for curettement. This was performed, and a microscopic diagnosis of endometrial hyperplasia was made.

About one month later, she was admitted to the Surgical Service for operation upon the colon, and, during the progress of this operation, a solid tumor of the left ovary was found and removed.

Pathologic Examination—*Microscopic* Dr T G Blocker, Jr. "The section reveals a remarkably uniform picture of cylindroid shells and cords of anaplastic epithelial cells intertwined with young fibrous tissue. The nuclei of the epithelial cells are regular in size and in shape, but as a whole they are elongated and vesicular with moderately sized nucleoli. The fibrous tissue, quite cellular itself with large nuclei, appears to have formed secondarily to the neoplasia resulting in more or less self-encapsulation process. There are no pseudofollicles formed."

Grossly, the specimen was covered by a serous endothelial membrane. Was firm and nodular. It measured 6x5x4 cm. There was slight tendency to lobulation and it was pinkish-yellow in color. **Pathologic Diagnosis** Cell tumor of the ovary—cylindroid.

We would theorize, if we may, that, perhaps, the case we report did not have a complete and normal menopause except as to the cessation of menstruation, that there was, for 14 years, sufficient estrogenic hormone stimulation to prevent atrophy of the uterus and endometrium but not sufficient to produce menstruation, but, when this estrogenic function reached a certain maturity or, perhaps, a certain balance of power, menstruation was resumed.

We wish to thank Dr A H Braden, Dr Paul Brindley, and Dr Truman Blocker, Jr, for their assistance in preparing this paper.

REFERENCES

- ¹ Dockerty and MacCarty. Granulosa Cell Neoplasm with a Discussion of Possible Histogenesis. *Amer Jour Obstet and Gynec*, 38, 698, October, 1939.
- ² Crossen and Crossen. *Diseases of Women*. 8th Edition, 761, 1935.
- ³ Pratt, F B. Granulosa Cell Tumors of the Ovary. A Review of the Literature. *Jour Obstet and Gynec, Brit Emp*, 44, October, 1937.
- ⁴ Novak, E. *Amer Jour Sur*, 24, 595-601, June, 1934.
- ⁵ Dockerty and MacCarty. Granulosa Cell Tumors. *Amer Jour Obstet and Gynec*, 37, March, 1939.

DISCUSSION—Dr S L LEDBETTER, JR (Birmingham, Ala.) I have never seen a patient with a granulosa cell tumor, but have been very much interested in ovarian tumors associated with secondary sex changes since operating upon a patient with an arrhenoblastoma. My attention was first called to this subject by reading the article by E Novak and J H Long, published in the *Journal of the American Medical Association*, September 30, 1933. One week later I saw the patient with the arrhenoblastoma. This has been re-

ported in detail by McLester in the Archives of Internal Medicine, 57, 773-786, April, 1936

I first saw this patient with Doctor McLester in October, 1933, and I am quite sure that we would not have recognized the disease had it not been for Novak's article. This patient was a young woman, age 32, with a history of seven pregnancies—five full term and two miscarriages. The youngest child was born in March, 1930. She nursed the child for several months, and menstruated on the fourth and sixth months after the birth of the child, and then stopped menstruating. Shortly afterward she noticed that she tired easily, began to lose weight, began to develop a beard, and to assume male characteristics. On examination we found that her voice was husky, she had a male type of figure, quite a heavy beard, so much so that it required daily shaving, a clitoris almost as large as the little finger, hair on the legs, male type of pubic hair, and a large tumor of the right ovary, the size of a grapefruit.

At operation, we removed a tumor of the right ovary. On the left side, coming off the broad ligament, there was another tumor of the same character, but much smaller, being about 2 cm. in diameter. The left ovary was fibrous and smaller than normal.

The patient made an uneventful recovery, and began to menstruate exactly 29 days following the operation. After ten days, her voice began to clear and, at the present time, it is perfectly normal except when singing, when it is apt to break. She has increased in weight, the breasts are more normal, there is very little hair on the legs, shaving is not necessary, and menstruation is normal.

DR ALBERT O SINGLETON (Galveston, Tex.) I might say this patient Doctor Baines reported had been through the Gynecologic Department, and they searched for the cause of the menstrual flow. She was referred to surgery for marked prolapse of the rectum. We were not particularly interested in the gynecologic side and were performing an intra-abdominal operation for the cure of the prolapse, when this tumor was observed and removed. The menstrual flow has not occurred since the tumor was removed.

DR FRANK L BARNES (Houston, Tex., in closing) I enjoyed Doctor Ledbetter's discussion and also his report of his case. I know very little about these tumors. The one I reported was one of my surgical surprises and I thought probably if I had another I could diagnose it with one operation instead of two.

THE MAINTENANCE OF PREGNANCY IN THE HUMAN AFTER REMOVAL OF BOTH OVARIES*

CASE REPORT

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EXPERIMENTAL WORK on such animals as the rabbit has demonstrated that the corpus luteum is essential to the maintenance of pregnancy during the first two or three months. Experiments on monkeys, reported by Carl Hartman,¹ tended to show that pregnancy could be maintained in these animals when ovariectomy is performed some time after nidation. How soon after nidation, however, the corpus luteum remains indispensable for the maintenance of pregnancy has been determined for only a few mammalian species. The pregnant rat, mouse, or rabbit, for example, almost invariably aborts after castration. In man the matter is under dispute. From the literature, many cases can be cited in which abortion was seen to follow removal of the corpus luteum, while there remain positive cases in which castration did not interfere with pregnancy.

Paul N. Leech, secretary of the Council on Pharmacy and Chemistry of the A. M. A., stated in a letter, dated July 25, 1939: "It is well-known at the present time that the removal of the ovaries after the third month of pregnancy in the human does not usually interrupt the pregnancy. S. A. Asdell² has collected from the literature a series of cases in which the ovaries were removed during pregnancy, and he found that most of the pregnancies proceeded in the usual fashion.

"Most authorities agree that the placenta takes over the function of the ovaries at this time and elaborates the various hormones which are normally found in pregnancy. The pregnandiol excretion of a pregnant castrate was found to be normal, which indicates that the placenta was elaborating a normal amount of progesterone. It, therefore, seems likely, according to endocrinologists, that *progesterone administration is not necessary in the woman* who has had her ovaries removed after the third month of pregnancy. The estrogenic and gonadotropic substances are also found in undiminished amounts in the urine following removal of the ovaries.

"It is also known that ovariectomy in monkeys, after the early stages of pregnancy, does not, in most cases, interfere with the pregnancy (Hartman)."

Dr. Virgil S. Counsellor of the Mayo Clinic, in reply to an inquiry, says: "It is quite generally agreed that the corpus luteum's imperative value is during the first two months of pregnancy, and its value decreases as pregnancy

* Read by title before the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

advances" He recommends prolon (progesterin derivative of corpus luteum) if there seems to be any irritation of the uterus and threatened miscarriage

Dr Emil Novak, also in reply to a letter, says "It is now quite clearly established that the corpus luteum, so indispensable in the maintenance of early pregnancy in such animals as the rabbit, is certainly not indispensable in the human female" He thinks, however, that it is advisable to use progesterone after the operation during the first half of the pregnancy

Dr Richard W Telinde states "I do not know of any case, in the literature, in which pregnancy has gone to term (in the human) after removing the ovaries as early as the second month There are a good many cases reported that have gone to term later, and the earliest one that I have ever heard of was at the end of the third month" Eiss³ reports a case of a woman four months pregnant, in whom both ovaries were removed, followed by normal delivery of a live baby at term

Case Report—M E T, female, age 34, married 15 years, para +, was admitted to the Medical and Surgical Memorial Hospital, June 20, 1939, complaining of severe pain in lower abdomen with pressure on the bladder and rectum, frequent urination, distention, nausea, and vomiting In 1929 (ten years ago), the right tube, ovary, and appendix were removed Eight years ago her only child was born She has had no other illnesses Her menstrual history is negative, last menstruation, April 9 to 14, since which time she has shown all the signs of pregnancy On June 16 four days before admission to the hospital, she was seized with a severe pain in her pelvis and left lower abdomen, accompanied by nausea and vomiting

Physical Examination—Temperature 100° F, respiration and pulse normal, WBC 11,200, neutrophils 90, Wassermann negative, Aschheim-Zondek positive, urine negative except for trace of albumin

Her abdomen was distended She was tender and rigid in the left lower quadrant On pelvic examination, a large, tender, fixed mass in the left side of the pelvis was found Uterus was about the size of a two months' pregnancy

On June 20, under general anesthesia, the abdomen was opened in the midline A considerable amount of free, blood-tinged fluid was found The uterus was about the size of a two months' pregnancy The right tube and ovary were absent The left tube and ovary, which were black and gangrenous from torsion, were removed

The pathologic report showed the ovary to be 9x6.5x4 cm, and both it and the tube showed marked congestion, hemorrhagic infiltration, and early, moist gangrene The corpus luteum of pregnancy is seen on gross-section This measured 18 Mm at its longest diameter The central part showed cavitation, the cavity being filled with bloody fluid The patient made an uneventful recovery

Progesterin, 1 cc, was started on the second postoperative day, and continued every other day for several weeks There were never any symptoms referable to absence of ovarian hormones The patient often complained of dizziness and nausea after the injection of the progesterin The progesterin was discontinued at the end of the fourth month On January 8, she was delivered of a normal, eight pound, male child Both mother and child are in good condition

This case is interesting chiefly because of

(1) The general impression that abortion is almost certain to result from the loss of both ovaries during pregnancy, especially during the first three months

(2) The almost universal belief that the pregnant woman is a poor surgical risk for abdominal and pelvic operations. Barring bad technic and infection, there is no reason why a pregnant woman should be a bad risk.

(3) The theory that it is necessary to give progesterin to balance the loss of the ovarian hormone during the remainder of the pregnancy. We are not sure that it is necessary to give progesterin, and if it is necessary, it is important to know the amount required and whether overdoses may not do more harm than good. Zondek⁴ has demonstrated that the prolonged application of large doses of follicular hormone on the nonpregnant uterus of a rabbit produce (1) hyperemia, (2) glandular-cystic hyperplasia of the uterine mucous membrane, (3) infarct-like necrosis of the muscle layer, and aseptic suppuration of the uterine cavity. If prolonged doses of the follicular hormone result in so much damage to the nonpregnant uterus, it must be apparent that overdoses of the corpus luteum hormone on the pregnant uterus must be guarded against.

(4) Finally, the mental and nervous state of the pregnant woman is badly damaged by the constant suggestions from everyone, including the surgeon, that she and the fetus are both in imminent danger from a surgical operation, and that if operated upon she must become a hospitalized invalid during the remainder of her pregnancy, and be subjected to great expense and great mental strain. Seven or eight months' pregnancy is enough without the added burden of fear and the addition of unnecessary expense.

REFERENCES

- ¹ Hartman, Carl G. Noneffect of Ovariectomy During Pregnancy in Rhesus Monkey. *Amer Jour Obstet and Gynec*, 37, 287, February, 1939.
- ² Asdell, S. A. Growth and Function of the Corpus Luteum. *Physiol Rev*, 8, 313, July, 1938.
- ³ Eiss, Stanley. Pregnancy with Bilateral Ovarian Cyst. *Amer Jour Surg*, 10, 338, November, 1930.
- ⁴ Zondek. *Jour Exper Med*, 63, 789, June 1, 1936.

MODIFIED KONDOLEON OPERATION FOR SCLEROSSED LEG WITH ULCERATION¹

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AND

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THE FOLLOWING QUOTATION from an article by A J Cokkims, in Mangot's *Postoperative Surgery*, 3, 3993-3994, describes very well the local skin lesions found in the condition we are describing

"Numerous morbid conditions occur in association with varicose veins, but they are dependent, not on the varices, but on the venous stasis, the blood stagnation, and the resulting local anoxemia, accumulation of toxic metabolites, and local tissue acidosis

"Associated skin changes are perhaps the most striking Eczematous dermatitis (varicose eczema) is a common result and is seen in various types—erythematous, scaly and weeping, it may be localized, or it may involve the whole of what is known as the ulcer-bearing area of the leg Pigmentation occurs in the form of brownish macules which coalesce to form large areas of discoloration, and which may ultimately also occupy the whole of the ulcer-bearing area Pruritus is very common, and dermatitis artefacta may result from scratching Other common results are alopecia, and a dry and hypertrophied skin

"Edema of the ankle and lower part of the leg occurs in advanced cases, but quite distinct from this is a brawny swelling of the limb which is sometimes seen, and which is caused by hypertrophy of the subcutaneous and deeper areolar tissues owing to lymph stasis An interesting result of the local hyperemia, and one to which attention has only recently been drawn, is a decalcification of the lower part of the leg bones"

In various text-books of surgery the injection treatment of varicose veins has been well described but no remedy has been suggested for those cases which do not respond to injection We, therefore, feel that it is advisable to emphasize again the advantages of the modified Kondoleon operation

Take, for example, the past histories of three of our typical cases

TYPICAL CASE REPORTS

Case 2 —A K, age 41, was admitted to the U S Veterans Hospital, April 11, 1938, complaining of ulceration of both legs For the past seven years he has had to wear bandages

* Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga, December 5, 6, 7, 1939

*Surgical Examination**—This man has on each leg almost complete encircling ulcers of long standing. He has persistently negative Wassermann and Kahn tests. The feet beyond the ulcers are edematous with marked scar tissue, almost an elephantiasis of the ankles and upper feet. There is an area above each ulcer of thickened scar tissue. The senior author made the following consultation note on admission:

The left leg, I believe, is untreatable except by amputation, as the circular ulcer is constricting the circulation and lymphatics so that any operative procedure would eventually be unsuccessful. The right leg is where the ulcer only goes two-thirds around the leg. I believe it would be worth while attempting a modified type of Kondoleon operation, cutting through the scar tissue down through the fascia and allowing



FIG 1—Case 2 U S Veterans Hospital. Anterior view following Kondoleon's operation upon both extremities with "well taken" skin grafts. Following this photograph another Kondoleon operation was performed posteriorly, in order to relieve any resultant edema or scar tissue.



FIG 2—Case 2 U S Veterans Hospital. Lateral view. Notice lack of edema in feet.

expansion and the possibility of anastomotic lymphatic circulation. If this were successful, excision of scar tissue and skin grafting would have a fair possibility of success (Figs 1 and 2).

Treatment—September 27, 1938 Modified Kondoleon operation, right leg. October 24, 1938 Pinch-grafts to right leg. November 4, 1938 Modified Kondoleon, left leg. Additional skin grafts, right leg. November 18, 1938 Pinch-grafts to left and right legs. November 25, 1938 Additional pinch-grafts, left leg. April 4, 1939 Kondoleon repeated posterior to previous incision of both legs. Undertaken because of some peripheral swelling following original procedure. May 5, 1939 Pinch-grafts, both legs. July 13, 1939 Discharged. Hospitalization days—one year three months. Following first operation—ten months, 16 days. Following second operation—three months, nine days. *Final Result* Both legs well healed, without pain or swelling.

*I am rather ashamed to include my initial consultation note on this particular patient, but I do so because I believe it will show that our opinion has changed since that time.

After the procedures enumerated above, this patient has two legs completely epithelized, with no edema of his feet and ankles, and a soft calf where previously the ligneous induration was present

Case 6—J R, age 45, was admitted to the U S Veterans Hospital, May 5, 1932, complaining of an ulcer of his left leg, which he states has been present since 1929, and for which he has used many types of salves

Surgical Examination—On the lateral aspect, middle third of the left calf, is an ulcer about 4x3 inches. Surrounding this ulcer is an area of pigmentation and brawny induration. The leg shows many moderate-sized varicose veins. Circumference of the left leg in this area is about three and one-half inches greater than the right. He was treated with ultraviolet ray and elastic stocking. The varicose veins were not injected. Discharged, June 28, 1932

Second admission, August 14, 1933. Discharged, November 21, 1933. Chief Complaint: Ulcer, varicose, left leg. Size at this time was 3x6 inches. He was treated by bed rest, ultraviolet ray, elastic stocking. Varicose veins not injected.

Third admission, August 15, 1935. Discharged, November 18, 1935. Following the last period of hospitalization, at which time the ulcer had been healed, there had been no difficulty with it until about two weeks before the present admission, when the ulcer again reappeared. At this time it was about 3x4 inches and showed a brawny, pigmented area surrounding it involving most of the middle third of the leg. Treated by ultraviolet ray, bed rest, and elastoplast bandage.

Fourth admission, February 14, 1936. Discharged, September 16, 1936. Ulcer was healed following last period of hospitalization until two weeks before present admission. Treatment by ultraviolet ray, bed rest, elastoplast bandage, and one varicose vein adjacent was injected. He was discharged as healed.

Fifth admission, December 21, 1936. Discharged, February 19, 1937. Ulcer stayed healed until four weeks before present admission. Examination at this time shows an ulcer 3x4 inches. Description same as on previous admission. Treatment by bed rest, ultraviolet ray, elastoplast bandage. Discharged as healed.

Sixth admission, March 31, 1937. Discharged, June 3, 1937. Examination: Ulcer 3x4 inches. Treated by bed rest, ultraviolet ray and elastoplast bandage.

Seventh admission, October 9, 1937. Discharged, November 29, 1937. Ulcer 3x4 inches. Treatment by bed rest, ultraviolet ray, elastoplast bandage.

Eighth admission, March 20, 1939, complaining of varicose ulcer of left leg. There have been seven previous admissions for this same condition. About six weeks ago the ulcer ruptured on the left leg. At this time it was 2x3 inches. There had been no recent injury.

Operation—April 27, 1939. Kondoleon procedure for varicose ulcer, chronic, left leg. There was a chronic, ulcerated area on the lateral surface, lower one-third of the left leg. The base of this ulcerated area was thickened and firmly attached to the fibula by firm, inflammatory adhesions. Beginning just above the level of the malleoli on the anterior surface of the left leg, a vertical incision was carried straight upward along the crest of the tibia to the extent of about eight inches. This was carried deeply through the skin, subcutaneous tissue and fascia and by splitting procedure to the site of the adhesion between the muscle layers. The tibialis anticus was placed laterally and posteriorly beginning and ending at the same level. The muscle was freed from the fibula. The two incisions were then connected by undermining, lifting up the entire area of skin, subcutaneous tissues and muscle, freeing all deep adhesions to the fibula. Bleeding was controlled and the resulting defects were tightly packed with vaseline saturated gauze.

Operation—June 1, 1939. Skin graft, left leg. The skin of both thighs was shaved

MODIFIED KONDOLEON OPERATION



FIG 3—Case 6 U S Veterans Hospital Note general swelling of leg widespread where skin grafts were applied In this case there should have been further incisions to release scar tissue



FIG 4—Case 1, New York City Hospital Photograph of ulcer before operation Note bronzing of skin, and size and chronicity of ulcer



FIG 5—Case 1, New York City Hospital Three years after operation Leg has remained healed during this period Skin is soft

and cleansed following which multiple pinch-grafts were taken from both thighs and transferred to the denuded areas on the left leg. When the operation was terminated, the grafted area was dressed and the leg placed in a light plaster encasement.

The majority of the skin grafts were successful. Subsequent splinting of the area with elastoplast bandage is completing epithelization. Patient remaining in the hospital. Granulation area now $1 \times 1\frac{1}{2}$ inches, roughly diamond-shaped (Fig 3), and improving steadily but slowly. Patient is ambulant and walks with slight limp. Surgical dressings only therapy.

City Hospital Case 1—H. K., age 44, was admitted to the New York City Hospital, October 30, 1936. Diagnosis: Varicose ulcers of both legs, right (Fig 4) worse than left. Duration, 19 years.

Treatment—Vein injection without success up till 1928. October 30, 1936. Ligation of veins of both legs. February 15, 1937. Ulcers excised and grafted. No improvement. March 22, 1937. Religation of right saphenous. April 23, 1937. Kondoleon and Thiersch grafts to right leg. June 10, 1937. Kondoleon on scar tissue on back of leg. June 14, 1937. Thiersch grafts to back of leg. June 30, 1937. Discharged with both legs healed and Unna paste boots. Legs healed in two months' time.

Follow-Up—Unna paste boots applied for almost a year. Right leg has stayed healed for three years (Fig 5). Left leg, which was not operated upon, ulcerated again. Some residual swelling in right leg. Bad hygiene and living conditions. Drug addict.

It is because of the great economic waste to both patient and hospital that we began our study of this group of long-existing ulcers that have resisted the usual types of treatment. Their appearance is characteristic. A leg with a constriction often clearly visible at the site of maximum ulceration, a pigmented, bronzed skin with one or several ulcers with dirty, unhealthy granulations. Often there is edema of the foot and ankle distal to the ulcer. On the palpation of the leg a ligneous consistency is felt, especially posterior to the tibia and fibula. This induration is confined largely to the pigmented area, and shades gradually into normal tissue cephalad to the lesion. Distal to the involved area the foot may be cold, edematous and moist. While in the early period of the disease varicose veins may be observed, at this late period they may not be noticeable. One must assume that either edema or repeated attacks of lymphangitis and phlebitis have caused their disappearance. We desire to emphasize that the treatment we recommend is not for early varicose ulcers that may be readily cured by injection of the veins with sclerosing solutions, rest and use of Unna paste boots. Many of our case histories show repeated hospital admissions during the previous ten or 15 years.

Our microscopic studies of tissues removed at operation reveal the following findings. Sections show an atrophic epidermis with loss of rete pegs and a very marked hyperkeratosis of the surface (Fig 6). Below the epidermis the subcutaneous tissue is practically replaced by a thick layer of heavy, fibrous connective tissue. This layer is about three times its normal thickness. Scattered through these fibers are large and small clumps of brown pigment, probably hemosiderin (Fig 7). The blood vessels are few and are surrounded and compressed by scar tissue (Fig 8). Around the vessels and under the epidermis there is an infiltration of lymphocytes and plasma cells. The glands are buried below the scar tissue and show markedly dilated ducts which are filled with secretion (Fig 9). This same scarring

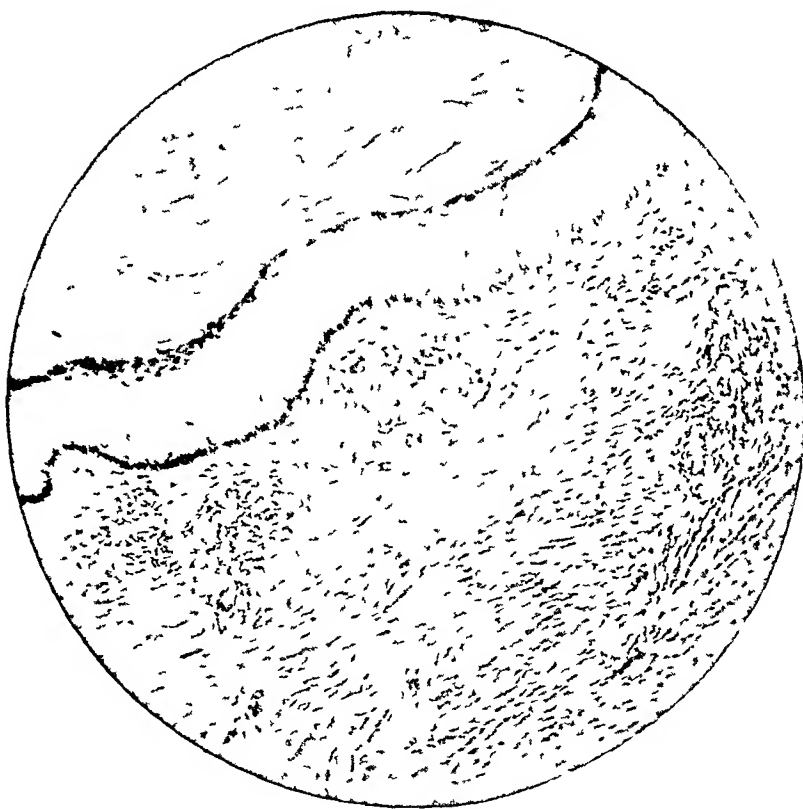


FIG 6—Atrophic epidermis. No hair. Compressed sebaceous and sweat glands. Marked fibrosis.



FIG 7—Scar tissue and deeper layer, showing marked pigmentation and chronic infection.

extends into the subcutaneous fat. The striking features in these sections are (1) The thinned-out epithelium without hair. (2) The dense scar tissue, with compression of the glandular structures and cystic dilatation of the ducts deep in the corium.

We are not claiming any originality in our procedure. Indeed, Hugh Trout, of this Association, in 1929, presented an excellent paper on this very subject. Trout reviewed the literature, giving great tribute, as do we, for the early and very constructive work of Doctor Matas and others. We have based the theory of our work on a slightly different concept than that held by Trout. Our operative procedure is predicated upon the concept that the encircling scar tissue is the main factor that prevents these chronic ulcers from healing. We believe with Trout that lymph and venostasis and infection are the inciting factors of this condition. We believe that after the constrictive scar tissue has been relieved, early skin grafting diminishes infection, prevents the secondary scar tissue formation, and, therefore, allows the reestablishment of the lymphatics. Whether that be by deep or superficial anastomoses has not been proven.

Operative Technique—The leg is prepared for several days preoperatively with wet 1:5,000 neutral acriflavine dressings and bed rest with moderate elevation—enough to empty the veins and still give the maximum of arterial supply.

At operation, two or three linear incisions are made from the healthy soft portion of the leg cephalad to the indurated area down to the edematous area of the foot and ankle. The incisions are usually made posterior or even with the tibia and fibula, and often one is made in the posterior third of the calf. The incisions are carried down through the scar tissue until soft, healthy tissue is encountered. In a few of our cases this necessitated exposing the posterior surface of the tibia and fibula. There is occasionally profuse bleeding from varicose veins encompassed by dense scar tissue. It may be necessary to control these vessels by suture.

The leg is treated by wet or vaselined gauze dressings. When the linear incision has been made, it is interesting to note how the wounds gape open, causing an increased circumference of the leg.

At first, we attempted immediate skin grafting, but had too many failures from delayed ooze or infection. Now we graft, usually by pinch- or small Thiersch grafts in seven to ten days, when the granulating surface is free from sloughs. It is important to emphasize the grafting before scar tissue again begins to contract the circumference of the leg.

Usually, the ulcers over the tibia are not attacked at the primary operation. In one or two cases they have been undermined by freeing their bases at the borders from the underlying deeper structures. If these ulcers are circular, surrounding the leg, the longitudinal incisions are carried through them.

It is interesting to note that after the Kondoleon procedure epithelization often takes place rapidly and the ulcers are almost healed by the time the leg

MODIFIED KONDOLEON OPERATION

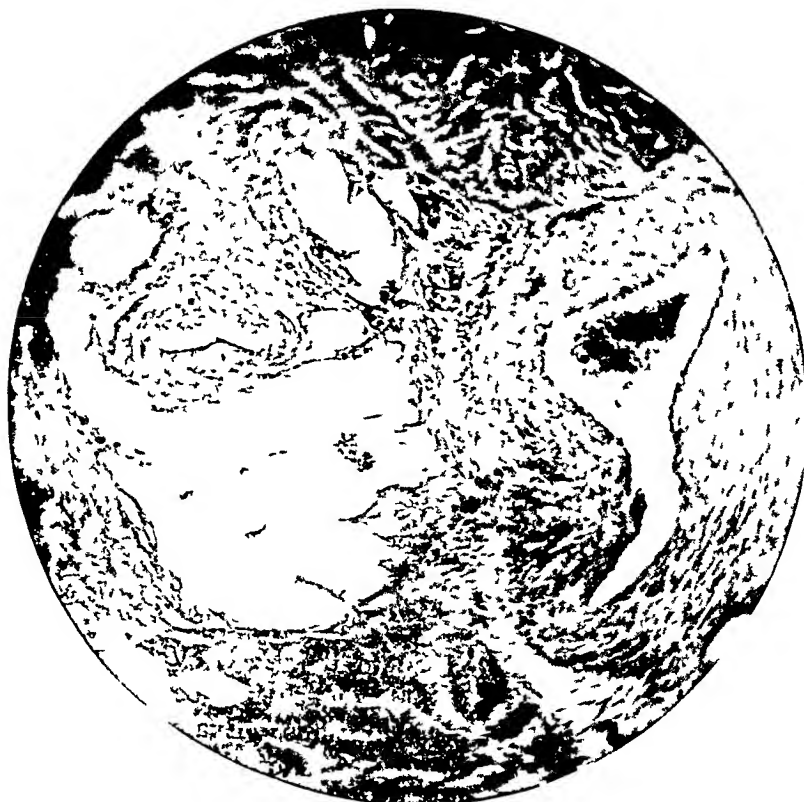


FIG 8—Blood vessels deep in fat surrounded and compressed by scar tissue Chronic infection

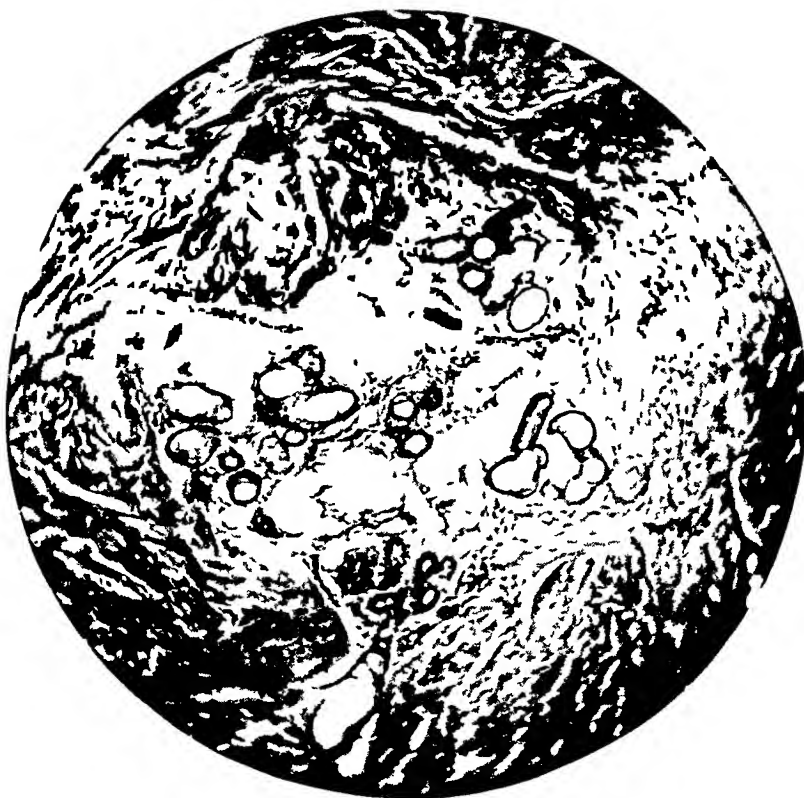


FIG 9—Dilated hair follicles deep in subcutaneous tissue

is ready to be skin-grafted. After epithelization is complete, whirlpool baths are efficacious to improve the local circulation. When the patient is first allowed up and about, either an Ace bandage or an Unna paste boot is necessary to prevent the initial static edema.

The brawny induration, noted before operation, begins to disappear while the patient is still in bed. When the patient first assumes the erect posture a mild static edema is apt to appear unless either Ace bandages or Unna paste boots are applied. For the first two to three months these cases must be closely followed to determine how long the bandages should be left on. Our poor results have been from too early removal of compression, allowing edema before the complete restoration of the lymphatic drainage has occurred.

We wish to present a preliminary report of 20 cases—ten from the New York City Hospital, nine from the U. S. Veterans Hospital No. 81, and one from the New York Infirmary for Women and Children, which we have included with the New York City Hospital cases.

ABBREVIATED REPORTS OF 20 CASES

Case 1—B. D., age 61, was admitted to the U. S. Veterans Hospital, June 27, 1938, complaining of an ulcer of the left leg, which had been operated upon one year before, necessitating a hospitalization of six months. Examination revealed infiltration and induration extending into the deep structures of the posterior aspect of his leg, responsible for the repeated breaking down of any surgical attempts to cover over the plastic and skin grafts. One-half of the material previously implanted still remained and appeared to be in fairly good circulatory condition.

Surgical Consultation—This patient, a man of 61, is suffering from an indolent ulcer on the posterior surface of the left leg. He was operated upon at the Veterans Hospital in San Francisco, with pedicle skin grafts. These broke down last January. The evidence at present is that two-thirds of the lower portion of the grafted area is filled with satisfactory skin. There appears a V-shaped ulcer 2½ inches, above this area, with a base of infected scar tissue. Palpating the leg anterior to this area, it has ligneous consistency.

I do not believe that any attempt at skin graft for the present ulcer would be permanently successful, without releasing adhesions lateral to the ulcer, through the fascia, in order to produce a better lymphatic and vascular drainage of the leg. I would suggest that he be treated by elevation and wet dressings for a couple of weeks, then a modified Kondoleon operation lateral to the ulcer, with immediate skin graft, and then, after a period of rest and elevation, an excision of the ulcer, with the skin tissue involved, should be performed, followed by either full-tissue or pinch-grafts.

The patient was treated by bed rest, elevation, radiant heat, whirlpool, and ultra-violet radiation, from June 27, 1938, to September 13, 1938, without improvement.

Operation—September 13, 1938. Two incisions were carried out, one mesial and the other lateral, one inch distant from the margins of the ulcer, paralleling the long diameter of the leg, carried down through the skin and subcutaneous tissue, musculature, to periosteum of the bone, relieving the tension in the tissues. The area, including the ulcer, blocked off by this incision was then lifted free from its attachments and allowed to remain as a bridging across the indurated area and beneath the ulcer. Apparently, the circulation in the immediate vicinity of the ulcer was improved by this procedure. No sutures were introduced. The leg was dressed with a vaselined dressing. No attempt was made to scarify or excise the ulcer proper. Ulcer healed promptly after this procedure without the necessity of skin grafting.

The patient was discharged, cured, December 1, 1938, after a total of five months and four days of hospitalization—two months and 18 days after the Kondoleon operation

Case 2—A K This case has been described on page 874

Case 3—M McG, age 48, was readmitted to the U S Veterans Hospital, October 14, 1938, complaining of a severe ulcer of the left leg, which had persisted since 1933

Readmitted, August 7, 1934 Discharged, December 3, 1934 Diagnosis Varicose ulcer left leg, severe *Treatment*—Consisted of local dressings, adhesive strappings and rest

Readmitted, May 13, 1935 Discharged, August 27, 1935 Diagnosis Varicose ulcer of left leg, 4x3 inches, with associated varicose veins *Treatment*—Injection of varicose vein Ultraviolet radiation to ulcer in addition to adhesive strapping and bed rest Decrease in size of ulcer primarily, only to return to original size

Readmitted, April 21, 1936 Discharged, June 19, 1936 Diagnosis Varicose ulcer of left leg Varicose veins left leg, moderate Since last hospitalization here (August 27, 1935) has been at Welfare Island for four months Has had 62 pinch-grafts, without success, ulcer 5x4 inches *Treatment*—Elastoplast, rest Pinch-graft, June 3, 1936

Readmitted, July 19, 1937 Discharged, September 24, 1937 Diagnosis Varicose ulcer, left leg, 2½x4 inches Varicose veins, left leg Thrombophlebitis, chronic, left leg *Treatment*—Rest, elevation of leg Elastic bandage Local dressings with gentian violet

Readmitted, October 14, 1938 Discharged, March 7, 1939 Diagnosis Ulcer, left leg, severe Was at Rikers Island five months, Bellevue one month *Treatment*—November 1, 1938 Kondoleon operation December 2, 1938 Skin graft December 16, 1938 Skin graft Whirlpool therapy following grafts Discharged Healed

Case 4—H H, age 37, was admitted to the U S Veterans Hospital, July 11, 1936, complaining of varicose veins, left, severe, right, mild Varicose ulcer, left leg He had had varicose veins for 12 to 14 years, and had also had numerous ulcers on his legs since 1925 The present one, duration six months, was one inch in diameter *Treatment*—Injection, rest, dressings Discharged September 17, 1936

Readmitted, January 16, 1939 Diagnosis Varicose veins, left leg Varicose ulcer, left leg, which had reappeared three months ago and which was growing progressively larger Now 3x4 inches *Treatment*—February 7, 1939 Kondoleon operation March 8, 1939 Pinch-graft Whirlpool therapy Discharged, April 20, 1939 Epithelized, with no edema

Case 5—C B, age 54, was admitted to the U S Veterans Hospital, February 27, 1934, complaining of a severe varicose ulcer on the left leg *Treatment*—Bed rest, adhesive strap dressings Discharged, December 14, 1934 Cured

Readmitted, June 14, 1935 Diagnosis Varicose ulcer, chronic, left leg One month following last discharge (December 1, 1934), ulcer again appeared Discharged, July 9, 1935 (AWOL)

Readmitted, October 8, 1935 Diagnosis Varicose ulcer, left leg, severe, three inches in diameter Thrombophlebitis, chronic, bilateral, legs *Treatment*—Elastic bandage, ultraviolet radiation, local surgical dressings Discharged, December 1, 1935 Cured

Readmitted, June 14, 1937 Diagnosis Ulcer, left leg, three inches in diameter *Treatment*—Rest, elastoplast, ultraviolet radiation, surgical dressings Discharged, August 11, 1937 (AWOL), condition improving

Readmitted, December 1, 1938 Diagnosis Varicose ulcer, left leg Phlebitis, left leg *Treatment*—January 11, 1939 Kondoleon operation, left leg January 31, 1939 Pinch-graft, left leg April 4, 1939 Kondoleon operation, left leg—cuff-like constriction following first Kondoleon operation to be relieved May 17, 1939 Pinch-graft September 15, 1939 Refused excision of scar tissue in base of previous Kondoleon operations Patient given physiotherapy and adhesive bridging—finally epithelized Dis-

charged, October 20, 1939 Epithelized but new skin appears thin with some edema still present

Case 6—J R This case has been described on page 876

Case 7—A S, age 48, was admitted to the U S Veterans Hospital, April 10, 1939, complaining of an ulcer of the right leg, which has been present since 1927 He had been treated in the Brooklyn Naval Hospital three years ago, and also by private physicians and himself, with no improvement *Treatment*—Kondoleon operation, April 27, 1939 May 17, 1939 Pinch-graft June 16, 1939 Debridement of scar tissue, at the site of the previous Kondoleon operation June 26, 1939 Pinch-graft August 19, 1939 Discharged Wounds well healed

Case 8—C C, age 42, was admitted to the U S Veterans Hospital, May 2, 1939, with a diagnosis of varicose veins of both legs, varicose ulcer, right leg Duration,



FIG 10.—Case 9 U S Veterans Hospital Final result with complete epithelization and lack of edema of foot

six months Numerous small ulcers with pigmentation Was treated with rest, local antiseptics and elevation Patient gives a history of pain and swelling with enlarged varicose veins of both legs, for the past five years About one year ago he developed some ulceration on the left leg which responded to injection treatment of the varicose veins and local treatment to the ulcers He has also been receiving injections and local treatment because of the large ulcers of the right leg for the past six months The right leg swells and becomes very painful

Surgical Examination—The left leg shows rather marked discoloration and increased pigmentation with numerous small, healed scars, the site of previous varicose ulcers There are no enlarged clusters or veins present at this time The right leg is dark, swollen and discolored The lower third shows increased pigmentation and many small, ulcerated areas, some of which are encrusted There are visible and palpable clusters of enlarged veins in the upper third of the leg and in the lower thigh, with many

small, hard areas, the site of previous infections. He gives a history of syphilitic infection and the lesions are suggestive of lues. Blood Wassermann is negative. Spinal puncture will be done and Wassermann done on the spinal fluid. *Diagnosis* (1) Varicose veins, both legs (2) Varicose ulcers, right leg (3) Thrombophlebitis, chronic, right leg

Treatment—July 12, 1939 Kondoleon operation, right leg. August 25, 1939 Skin graft, right leg. The majority of the skin grafts were successful. Remaining in hospital

Case 9—J B, age 46, was admitted to the U S Veterans Hospital, May 27, 1939, for varicose veins, varicose ulcers in both legs. Previous treatment in 1937 for same condition. Recurrence about ten months ago. Ulceration had been present since 1920. Nine admissions to various hospitals. Numerous ulcers.

Treatment—June 8, 1939 Kondoleon operation, right leg. July 13, 1939 Skin graft. Remaining in hospital (Fig 10)

NEW YORK CITY HOSPITAL CASES

Case 1—H K. This case has been described on page 878

Case 2—J H, male, age 54, was admitted to the New York City Hospital in 1935, for varicose ulcers of both legs, for "years." Swelling and scleroderma. *Treatment*—1933-1934 Injection of veins. Right leg healed, but developed osteomyelitis of foot. Left leg did not heal. 1935-1937 Several attempts to graft left leg ulcer failed. April 30, 1938 Kondoleon operation upon lateral side of left leg. May 12, 1938 Pinch-grafts. May 27, 1938 Pinch-grafts. June 30, 1938 Pinch-grafts. Ulcer healed and swelling disappeared.

Follow-Up—November 16, 1939 Left leg has remained healed and free of swelling. Scleroderma still present. Right leg had to be amputated because of infection.

Case 3—N R, female, age 58, was admitted to the New York City Hospital, May 10, 1937, and presented swelling of left leg, following a hysterectomy 15 years ago. Ulcers developed 13 years ago. Healed once but recurred. Has large sloughing ulcers on both sides of left leg. *Treatment*—May 21, 1937 Kondoleon incisions on either side of leg, through ulcers. May 25, 1937 Pinch-grafts to outer incision. May 28, 1939 Pinch-grafts to inner incision. June 29, 1937 Discharged healed.

Follow-Up—November 16, 1939 Leg still well healed. Skin around leg soft (Fig 11, 12, 13 and 14)

Case 4—A L, male, age 38, was admitted to the New York City Hospital, May 9, 1939, complaining of a varicose ulcer, right leg, with swelling. *Treatment*—1935 Injections, without success. May 10, 1937 Kondoleon incision through ulcer. May 17, 1939 Thiersch grafts—took poorly. July 24, 1939 Discharged healed but without Unna paste boot.

Follow-Up—November 16, 1939 Right leg very swollen. A few superficial ulcerations. Right leg three inches larger than the left. Referred for further rest and Unna paste boot.

Case 5—C G, male, age 73, was admitted to the New York City Hospital, March 25, 1938, complaining of varicose veins, and intermittent ulcers of the left leg, 12 years. *Treatment*—April 11, 1938 Leg healed with bed rest, but scar tissue remained, so a Kondoleon incision was made through the ulcer area. Thiersch grafts applied with 95 per cent takes. May 27, 1938 Discharged healed, with Unna paste boot. Uncooperative and had some breaking down of wound.

Follow-Up—June, 1939 Leg healed and no swelling.

Case 6—J W, male, age 54, was admitted to the New York City Hospital, May 1, 1939, complaining of varicose veins for years, and an infected ulcer for seven weeks. *Treatment*—May 5, 1939 Kondoleon incision on outer side of leg. Fascia removed.

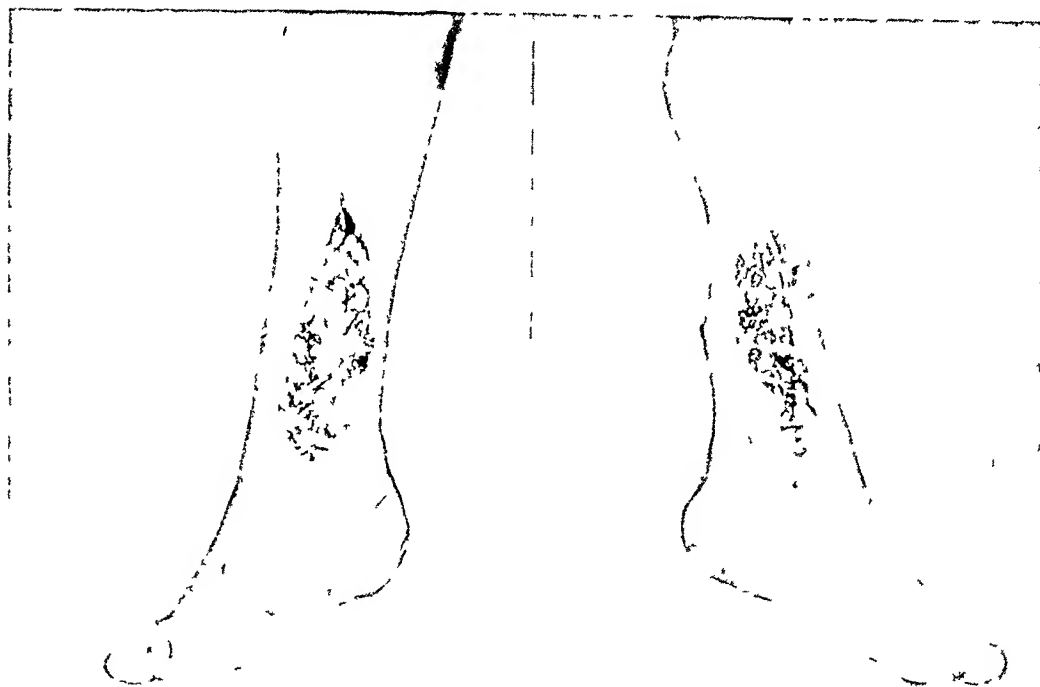


FIG 11—Case 3 New York City Hospital
After grafting the lateral surface of the leg
following Kondoleon operation. Note wide spread
of the skin.

FIG 12—Case 3 New York City Hospital
After grafting area of Kondoleon operation on
mesial surface of the leg.



FIG 13—Case 3 New York City Hospital
Final result two and one half years after opera-
tion—lateral surface of leg.

FIG 14—Case 3, New York City Hospital
Two and one half years after operation—mesial
surface of leg. Note softness of skin, with
pliability and lack of edema of foot.

MODIFIED KONDOLEON OPERATION

May 16, 1939 Pinch-grafts June 6, 1939 Went home against advice Not quite healed Ace bandage on leg

Follow-Up—November 16, 1939 A few superficial ulcerations and some swelling

Case 7—M B, female, age 41, was admitted to the New York Infirmary, July 20, 1939, and presented a varicose ulcer of the left leg, of 15 years' duration *Treatment*—1924 Leg ulcerated and healed spontaneously after one year 1928 Ulcerated again, and healed after three to four months June 31, 1939 Ulcer opened again and would not heal July 31, 1939 Kondoleon incision through outer side of leg Pinch-grafts applied immediately August 22, 1939 Discharged healed with Ace bandage

Follow-Up—September 20, 1939 Did not apply bandage properly and small ulcerations began to appear Put to bed and Unna paste boot applied November 10, 1939 Boot removed Leg healed Admitted to hospital for arthritis November 24, 1939 Leg well healed and tissues soft

Case 8—T W, male, age 61, was admitted to the New York City Hospital, June 2, 1939, complaining of a varicose ulcer of the left leg, which had been present off and on for 30 years *Treatment*—June 12, 1939 Kondoleon incision both sides of leg Pinch-grafts August 3, 1939 Went home against advice, not quite healed

Follow-Up—None

Case 9—L I, male, age 54, was admitted to the New York City Hospital, June 12, 1939, complaining of varicose ulcers on the calves of both legs Swelling of the left leg present for "years" *Treatment*—June 12, 1939 Kondoleon incision on both sides of left leg Thiersch grafts immediately June 22, 1939 More Thiersch grafts June 29, 1939 Pinch-grafts August 15, 1939 Discharged healed

Follow-Up—None

Case 10—F L, female, age 41, was admitted to the New York City Hospital, April 10, 1939, complaining of varicose ulcers of both legs, with swelling for 16 years *Treatment*—April 1, 1939 Bilateral saphenous vein ligation No improvement April 19, 1939 Kondoleon incision, right leg, with fascial strip removed April 26, 1939 Kondoleon incision of left leg, and skin grafts to right leg May 17, 1939 Thiersch grafts, both legs May 31, 1939 Thiersch grafts, both legs June 19, 1939 Scar tissue on right leg incised and Thiersch grafts applied June 26, 1939 Thiersch grafts to right leg August 5, 1939 Transferred to Welfare Hospital August 30, 1939 Discharged improved

Follow-Up—None

Case 11—W C, male, age 68, was admitted to the New York City Hospital, April 20, 1939, complaining of a varicose ulcer of the left leg, duration, ten years *Treatment*—Injections, without success May 1, 1939 Kondoleon incision to left leg, with fascial strip removed May 8, 1939 Pinch-grafts May 16, 1939 Pinch-grafts May 26, 1939 Pinch-grafts June 27, 1939 Finally healed Tissues sluggish July 1, 1939 Discharged

Follow-Up—November 16, 1939 Large deep ulcers of both legs Probably some arteriosclerosis responsible for this failure

ANALYSIS OF 20 CASES

Age incidence 37–73 years

Wassermann tests negative in all cases

Sex distribution 17 males—three females The ten cases from the U S Veterans Hospital were, naturally, all males, so this does not give a true sex ratio

Average duration of ulcers, 14 years

Of these, two were of short duration

One had varicose veins for ten years but ulcer for only six months

One had varicose veins for "years," but an acute ulcer with infection of seven weeks' duration

Follow-Up

Twelve cases healed

Six from the U S Veterans Hospital were discharged after ample observation to assure healing

Six from the New York City Hospital stayed healed for three months to three years

Two cases still under observation at the U S Veterans Hospital

Two fair results from the New York City Hospital need further

Unna paste boot treatment to relieve edema and superficial ulceration

Three cases not followed

Two left against advice when not quite healed

One discharged healed

Two failures

CRITIQUE OF THE TWO INSTANCES OF FAILURE

Case 5 —C B, New York City Hospital group This was a male, aged 54, who was first admitted in February, 1934, with varicose ulcer of the left leg. He had three subsequent admissions. The ulcer kept recurring. The first Kondoleon operation was not extensive enough. A second Kondoleon operation was performed three months later. The leg was not grafted for six weeks. He left the hospital against advice, before the ulcers were completely healed, and has not been seen since. Failure was anticipated, because of poor after-care.

Case 11 —W C, New York City Hospital group This was a male, aged 68, who had had varicose ulcers for ten years, which repeated injections had failed to heal. The Kondoleon operation was followed by pinch-grafts in one week. He had two subsequent graftings, all of which healed sluggishly. The patient was discharged, healed, after two months. An Unna paste boot applied but not left on long enough. When seen, November 16, 1939, had large, deep recurrent ulcers on both legs. Arteriosclerosis was probably a factor in this case.

SUMMARY

Our follow-up is not as complete as we could wish—largely because the U S Veterans Hospital draws from other than the metropolitan districts and because the New York City Hospital has a very poor and migrant clientele. The hospitalization period at the U S Veterans Hospital is longer than would occur elsewhere, as the Government charges are kept until they are completely healed. They leave with a better chance of permanent cure than do the New York City Hospital cases.

We have had one severe failure, noted previously, and two cases that

have had slight recurrences that will need minor procedures to relieve the edema and superficial ulcerations

In analyzing our failures there are three important causes that we hope to correct in the future

(1) Incisions have not been long enough in some cases

(2) There has been too long delay between the initial incision and secondary skin grafting In a busy hospital service it is difficult sometimes to get operative time for skin grafting

(3) Immediate follow-up as to treatment of the dermatitis following the grafting, and application of Unna paste boots or Ace bandages, has been incomplete in two cases

The question can be raised as to whether there may not be late recurrences in our cases We feel, from our examinations on discharge and follow-up, that the lack of edema in the foot and the return of the tissues to normal consistency promise a permanent cure and return these patients to active life with the greatest rapidity

In observing cases treated by elevation, rest and wet dressings, we have not seen the above mentioned changes after they are up and around again

DISCUSSION —DR A G BRENIZER (Charlotte, N C) These people we say have phlebitis, but do they have phlebitis or lymphangitis? If we do not do something for the lymphangitis, they will not heal Doctor Bancroft has found out that certain of these cases of so-called varicose ulcer will not heal until a very radical operation, like a modified (not so extensive) Kondoleon, is performed That operation was originally undertaken to reestablish a wider and more abundant anastomosis between the superficial and deep lymphatic vessels

The speaker then showed photographs of a very extensive ulcer of the leg, which demonstrated splendidly an ulcer as big as two hands, covered with full-thickness Reverdin grafts The leg was not even swollen (edematous) because it had been elevated and the graft-bed prepared for three weeks Yet, later, when the leg was put to the floor and the edema returned, three-fourths of the grafts, after "taking," sloughed and were lost Next, he showed a marked lymphangitis (elephantiasis), very much improved by the Rogers-Kondoleon-Sistrunk operation He then demonstrated, by a series of photographs, the healing of grafts where the vessels were tied and sloughing where they had not been tied

His point was That though the blood vessels are tied or a complete or incomplete Kondoleon operation performed, the improvement comes from the relief of the lymphangitis rather than of the phlebitis

DR HUGH H TROUT (Roanoke, Va) There is a certain percentage of cases following such operations in which there will be recurrences We have had this experience, and, recently, we have tried out a drug which is mentioned at every medical meeting nowadays, namely, sulfanilamide We have had satisfactory results in two cases with its use These recurrences are usually preceded by attacks of so-called "erysipelas", then they get over one attack and then repeat, and then, after several such attacks, "elephantiasis" or an "elephantoid state" begins to develop We had quite a few recurrences before the days of sulfanilamide but since then we have only had two one a filaria with superimposed streptococcic infection, with attacks of fever

on an average of once a month, the other an uncomplicated streptococcic infection. The first case was two and one-half years ago. After putting her on sulfanilamide, for the first time we obtained a quick result as regards reduction of fever and the disappearance of the infection. She has taken sulfanilamide two or three times a month, which has apparently prevented the recurrence of these attacks. The other case is more recent and we cannot say much about it yet, but I can say we believe sulfanilamide is well worth consideration as a preventive of these recurrent attacks of streptococcal infections.

DR M. STANLEY-BROWN (New York, N. Y.) The operative technic which has just been described is a comparatively simple one but the procedure as a whole is beset with pitfalls. Some of our poor results and failures illustrate this very well.

To begin with, the patient must be cooperative and willing to follow instructions for a period of six months or more. Great care must be taken in the selection of the cases. The City Hospital failure was a good example of this. There were impaired arteries along with varicose veins and edema, and the trauma of operation was more than the circulation could stand. The best time to operate is when there is the minimum of infection and edema. Whenever possible it is preferable to give the patient a period of bed rest, elevation, and wet antiseptic dressings before operation. Whirlpool baths, used during this period, are often of great assistance. Some of our delayed healing and failures of our grafting have been due to disregard of this principle.

At operation, one of the difficulties is profuse bleeding. The veins are held wide open in scar tissue and cannot be clamped easily. An Esmarch bandage may be used on the thigh to facilitate the procedure. If the incision is begun below and carried upward, the veins in the ankle may be easily ligated before they enter the scarred area, and excessive bleeding reduced.

When we first began to employ this operation, we used to remove a strip including skin, subcutaneous tissue and fascia for the entire length of the incision. This, however, is not necessary, as a single incision through the involved gapes open sufficiently to relieve tension and afford adequate drainage.

The incised area should be as clean as possible for skin grafting. A solution of 1:5,000 acriflavine is very nonirritating and cleans up granulations rapidly. Unless the field is very clean, pinch-grafts are the ones of choice, though occasionally in selected cases Thiersch grafts have been used with success. Immobilization of the extremity following grafting is of great importance and plaster of paris should cover from foot to midthigh. Grafting must be undertaken within a week after the initial operation.

I cannot emphasize too strongly the importance of immediate and late postoperative care. The patient should be kept in bed with moderate elevation of the leg until healing is complete. The leg should not be allowed to hang over the side of the bed, or the patient allowed to walk without the support of an Ace bandage, properly applied, or an Unna paste boot. Few of our patients have the intelligence to apply a bandage properly, so our best results have been with a boot. It requires from three to six months to restore circulation and proper lymphatic drainage, and during this period edema must be kept out of the leg. By this, further scar formation is prevented and the return of a normal consistency to the tissues, and a chance of permanent cure is assured.

The average hospitalization time of these cases is about two weeks before operation and six weeks to two months after operation. This may seem long, but with a history which averages 14 years of ulcer, which heals and breaks down repeatedly, and frequent periods of hospitalization, it is an economy of time in the end.

DR HOWARD MAHORN (New Orleans, La.) We have arrived at somewhat the same idea as Doctor Bancroft has in treating these cases, though from a little different angle. Several factors are responsible for keeping these ulcers open, which are Back pressure, infection, and in long-standing cases, scarring. It is necessary to get rid of each one to cure the patient.

The speaker then demonstrated, photographically, a case with perfectly huge varicose veins. The leg was brawny and indurated in the lower part. If this area ulcerated and the ulcer remained open for any length of time she would have the same condition he described. Some years ago we started ligating these veins. The important thing is to ligate them high, but we found a number of cases that had additional leaks below the saphenous which are not affected by high ligation. Furthermore, we found that injections of sclerosing solution only, are not sufficient to hold back the pressure in these cases. For that reason we cut out segments of veins where these additional leaks from the deep to the superficial veins occurred. It was possible to foretell where the leaks were by certain tests. The "Comparative Tourniquet Test" will localize the level of incompetent communicating veins. In addition to high ligation of the saphenous vein and excision of segments of superficial veins into which communicating veins with incompetent valves permit additional backflow from the deep to the superficial system, where there is much scarring from long-standing ulceration, the ulcer bed is cut out and the area grafted with skin. In certain cases when there is much fixation, in removing varices below the knee, I excise indurated tissue around the veins even through the deep fascia and for the distance of the entire leg.

This is a very interesting and significant contribution Doctor Bancroft has made, an advance in treatment of these very difficult cases.

DR ROBERT L. RHODES (Augusta, Ga.) If you will recall, at the White Sulphur meeting in 1923, I presented the subject of elephantiasis and its relation to focal infection and reported several cases of recurrences following the Kondoleon procedure. In one instance the recurrence was caused by infection of the tonsils, and pockets of pyorrhea around several teeth. He was promptly relieved by the removal of the foci of infection and remained well over a period of ten years, after which time he moved away and was lost track of. Another strikingly similar case was observed about one year later.

SEMILUNAR CARTILAGES*

FRANK P STRICKLER, M D

LOUISVILLE, KY

INJURY to the semilunar cartilage is one of the most common knee joint injuries. With increased industrial activities, auto accidents, football, baseball, basketball, *etc*, every surgeon is seeing larger numbers of these cases. Quite a few general surgeons are operating upon these patients, and well they may, for after all, who is better fitted to open a knee joint than a general surgeon?

I have been interested in this subject for some time, and have seen a number of these cases. My interest progressed to such a degree that, for my own use, I have devised several instruments which have been of assistance in making the operation easier and reducing operative trauma, at least from my own viewpoint.

I have always been of the opinion that the accepted period of convalescence for these cases was too long, and that this period should be reduced. With these suggestions in mind, let us consider injuries of the semilunar cartilages.

The internal cartilage is far more frequently injured than is the external. There is an anatomic basis for this which I will not touch upon in this paper. The internal cartilage is injured and displaced when strain is put on the internal lateral ligament of the knee joint, with the knee flexed and the femur rotated inward. The internal semilunar cartilage is nearly always displaced inward, and as the cartilage is wedge-shaped, it may become jammed between the bones forming the knee joint, locking the joint and producing excruciating pain. When the internal cartilage is occasionally and rarely displaced outward, the protrusion can be palpated from the skin surface and the knee joint does not lock. Locking of the knee joint, however, is not always present in these cases, for in about one-third of the injuries to the internal semilunar cartilage, the history of locking is absent. This should always be kept in mind, and the absence of a history of joint locking does not mean there is no cartilage displacement or damage. Injury to the internal semilunar cartilage can also at times produce symptoms on the outer side of the joint, and it is well to recall that the external cartilage is not frequently injured.

When these patients present themselves, they usually give a history of a chronic knee condition with little or no mechanical treatment. If they have had mechanical treatment it has, as a rule, been so inadequate as to be of little or no value to the patient. The acute displacements of the internal cartilage, in a large number of instances, seem to be treated by a friend or an athletic coach, who gives the subject a yank on the leg and "calls it a day." The

* Presented before the Fifty-Second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

average patient has a superstitious horror of a surgeon looking into his knee joint. Consequently, the surgeon is the court of last appeal.

All of these patients should have their knee joints examined roentgenologically. Not that the roentgenogram will show the offending cartilage, but to rule out other conditions that could be mistaken for a displaced cartilage. However, some surgeons inject oxygen into the knee joint in an endeavor to show the cartilage. This may or may not be successful.

The physical findings in these patients are not remarkable. Injury to the internal semilunar cartilage is diagnosed by its acute onset, synovitis and swelling of the joint, locking of the knee joint, pain on the inner side of the patella localized over the internal cartilage. Occasionally there is palpable irregularity over the cartilage. There is also tenderness over the internal lateral ligament and tenderness over the cartilage when the knee joint is forced into extension. A history of the injury is also of help.

Symptoms of injury to the external semilunar cartilage are not as well defined as those of the internal semilunar cartilage. The patient complains of pain over the cartilage, and may feel something slip over the outer surface of the knee joint. There may also be a clicking over the outer surface of the knee joint on flexion or extension of the joint.

There are two types of treatment for displacement of the internal semilunar cartilage.

(1) *The mechanical treatment* (which should be followed in all acute cases), and by this I mean the ones seen immediately following the injury. The patient has severe pain with marked muscle spasm. Therefore, in reducing the dislocated cartilage, an anesthetic should be administered. The steps for reduction are *acute flexion, lateral deviation, internal rotation, and complete extension*. Following reduction, the knee should be immobilized for three weeks to give time for union of the cartilage to become established. At the end of this time, the patient should have massage, the shoe raised one-quarter of an inch on the inner border heel and toe to relieve the strain on the internal lateral ligament. The patient should also wear a knee brace or cage for several months, which further controls motion at the knee joint. By following this outline of treatment, acute cases are given a chance to heal without operation. The conservative treatment is time-consuming and cannot be hurried.

(2) In those cases which have run a chronic course, with much discomfort and disability, the *operative treatment* is indicated, and it is in these cases that we are especially interested. To give a better view of the interior of the knee joint during the operation, the patient is placed on the operating table with the knees flexed to a right angle hanging over the table. We employ tincture of merthiolate for the skin preparation, and make the skin incision through sterile gauze. The usual incision is made about $1\frac{1}{2}$ –2 inches long, and extends obliquely from the lower angle of the patella to the tibial margin. Thin gauze sponges are clipped to the skin edges of the wound with skin clips.

The most rigid aseptic technic is observed and nothing is touched with the fingers. Perfect hemostasis is also secured.

For working inside the joint, we use angulated hooks for grasping the cartilage, and a right angle angulated knife for cutting the cartilages free, also an angulated V-shaped knife with the cutting surface in the V. We also use angulated scissors, and have two sets of retractors adjusted to the proper angle,

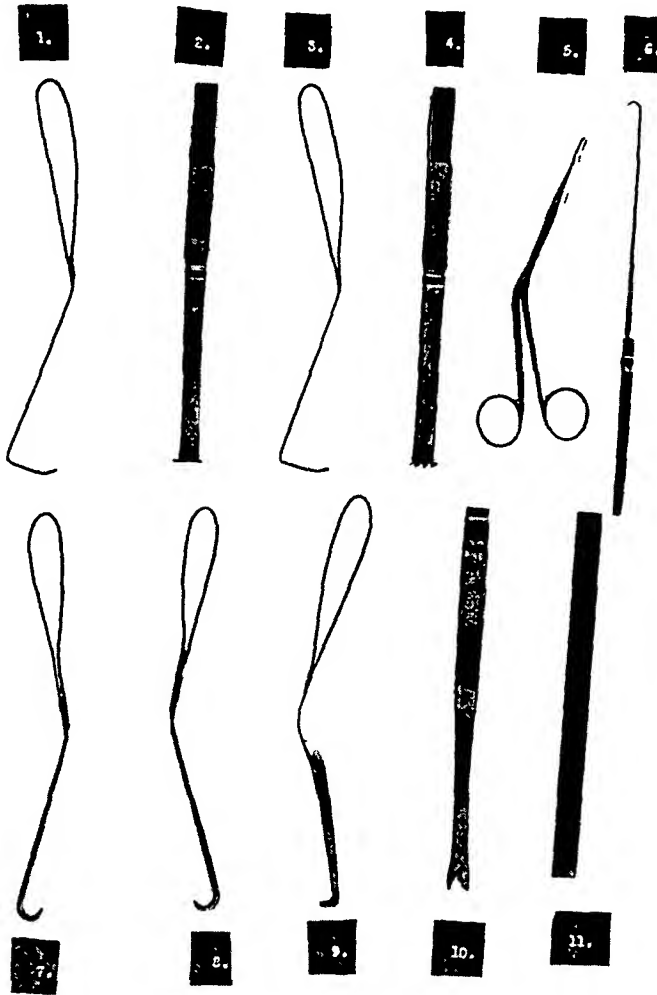


FIG. 1.—Illustrates instruments for operating upon the inside of the knee joint. Nos. 1, 2, 3, 4 are blunt and toothed retractors. No. 5—Angulated scissors. No. 6—Small hook for tags of cartilage. Nos. 7 and 8—Angulated hooks for larger cartilage tags. No. 9—Right angle knife. No. 10—V shaped knife with the cutting surface on a V. No. 11—A flat or spatula retractor.

one pair blunt, the other with teeth. These instruments are not expensive, nor as complicated as they may seem (Fig. 1).

The joint capsule is opened, retractors properly placed, and the cartilage in question thoroughly examined. The cartilage may be found detached at either end, split, or detached in the middle along the internal lateral ligament, *etc.* The cartilage is grasped between the spatula or flat retractor and one of the hooks in order to firmly hook the cartilage. The cartilage is then com-

pletely removed with the angulated knives or scissors, leaving no fringes or tags. The wound is closed with interrupted sutures of fine chromic catgut in layers. In men, we pay no particular attention to skin closure. In women, we use a subcutaneous suture for the cosmetic effect. A compression dressing is applied, and the patient returned to bed with no splints of any kind. The knee is slightly flexed on a pillow, ice bags and small amounts of opiates are employed to control pain.

Twenty-four hours later, and never longer than 48 hours, the patient is out of bed walking with one crutch. We firmly believe that early walking and weight-bearing prevents adhesions in the joint, diminishes muscular atrophy, prevents joint stiffness, and makes a large amount of massage, diathermy, *etc*, unnecessary. It also markedly cuts down the time of postoperative convalescence. Our cases are back at work in four or five weeks from the date of the operation.

In reviewing the literature, I find that all sorts of plaster encasements, splints and braces are put on these patients postoperatively, and that knee joints are often immobilized anywhere from ten days to three weeks. This, I consider to be absolutely unnecessary. After all, no important anatomic structures of the joint are involved other than the capsule and the cartilage. The ligaments are never disturbed, and the strength of the joint should never be impaired by this operation.

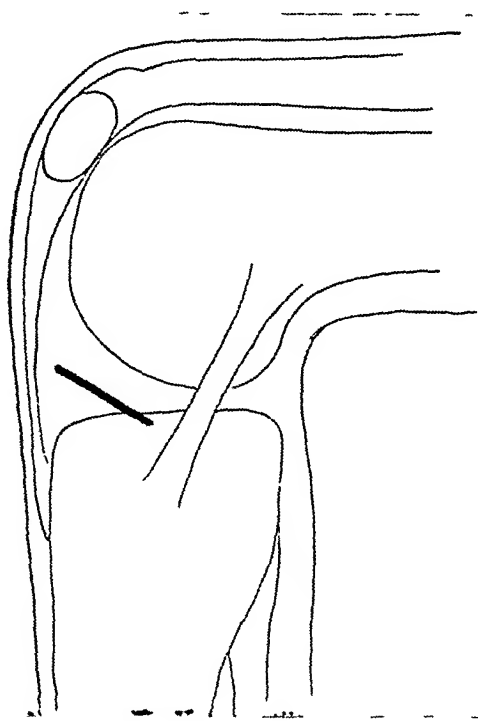


FIG. 2—Schematic drawing of the knee joint showing the location of the incision, this incision in no way impinges on any of the important ligaments of the knee joint.

SUMMARY

This paper has been presented to call attention to the postoperative treatment of semilunar cartilages, in order to demonstrate that the convalescence of these patients can be shortened, also, to present instruments that facilitate the removal of the semilunar cartilage without damage to the joint surfaces or its synovial membrane, as, in my opinion, operative trauma definitely plays its part in postoperative discomfort, delayed convalescence and poor results.

THE USE OF PRESERVED CARTILAGE IN EAR RECONSTRUCTION^{*}

HAROLD L. D. KIRKHAM, M.D.

HOUSTON, TEXAS

THE RECONSTRUCTION of ears, either partial or total, has long been one of the most disappointing and unsatisfactory branches of plastic surgery. This is due in large measure to the complicated form of the ear cartilage or scaffold, making it extremely difficult to carve and pattern rib cartilage so that it will be thin enough and light enough to preserve the normal position and appearance of the new ear. Rib cartilage has been employed because of the unavailability of elastic cartilage in large enough amounts and shapes. It is obvious from this premise that the chief difficulty in ear reconstruction has been to obtain a suitable scaffold or mold upon which to reconstruct an ear. If any thin, light reproduction of ear cartilage could be formed, even though a foreign body, and used as a foundation, the reconstruction would be simplified and the ultimate result should have a more pleasing cosmetic appearance. What better mold could one use than ear cartilage itself, if, when transplanted, it would remain as cartilage and remain *in situ*.

Some years ago the author became interested in the fate and behavior of transplanted rib cartilage, which occupies an unique position as regards its life and existence. For many years the excess costal cartilage removed in the course of a plastic reconstruction has been stored by burying it in a subcutaneous pocket in the abdominal wall, and here it remained indefinitely, and intact, for such future use as might be necessary. Despite the opinion of some authorities that much transplanted cartilage, in time, becomes absorbed or fibrosed and converted into fibrous tissue, studies of this transplanted cartilage, as shown in Figures 1 and 2, have definitely convinced the author that this is not true, but that cartilage remains permanently as cartilage.

The behavior of transplanted cartilage in remaining as such led to the belief that cartilage might be transplanted after death, and still retain its character, which, if true, would solve some of the difficulties of ear reconstruction. It was necessary to determine (1) Is the behavior of elastic cartilage identical with the behavior of rib cartilage? (2) Could elastic cartilage be employed as a heterogenous graft? (3) If it could be employed as a heterogenous graft after death—how long after death would this be possible? Accordingly, a series of experiments were performed upon rabbits to answer these questions.

Rabbit A was killed, and one hour after death five pieces of ear cartilage were removed. Two of these were placed on ice dry, and two on ice moist in Ringer's solution. The fifth piece was planted in the abdominal wall of Rabbit B. Each hour thereafter another piece of ear cartilage was removed.

^{*} Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

from Rabbit A and planted in the abdominal wall of Rabbits C, D, E, F and G, respectively. At the end of 24 hours a piece of wet and dry ice-box cartilage was planted in Rabbit H, and at the end of 48 hours this was repeated in Rabbit I. These rabbits were watched for a period of six months, one however, dying in the interim, namely, the three-hour rabbit. After six months

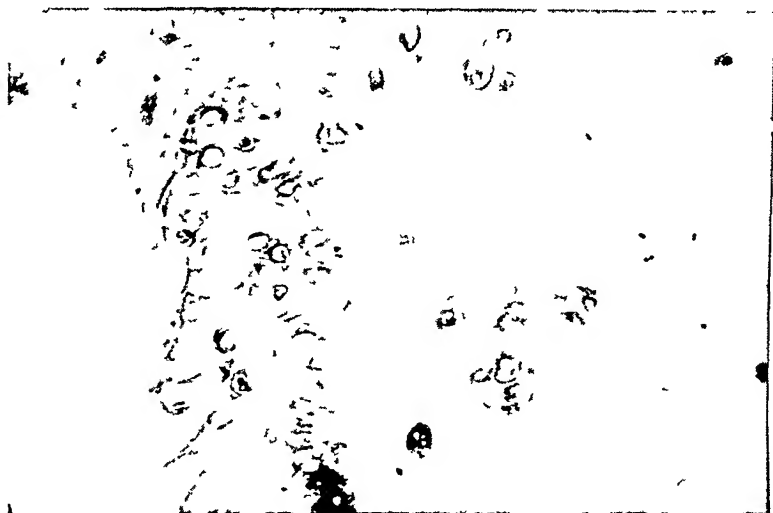


FIG 1—Rib cartilage after autogenous transplantation for ten years

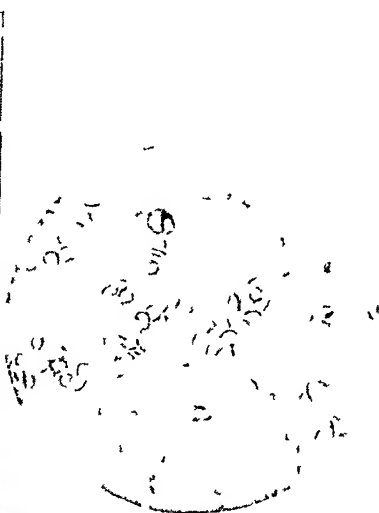


FIG 2—Rib cartilage after autogenous transplantation for eight years

the wounds were opened, the cartilage removed and sectioned (Fig 3), and with the exception of the dry, iced cartilage all were intact, and showed the characteristics of cartilage, though the cell spaces were vacuolated, the nuclei having disappeared, and the cartilage dead. This answered the three ques-

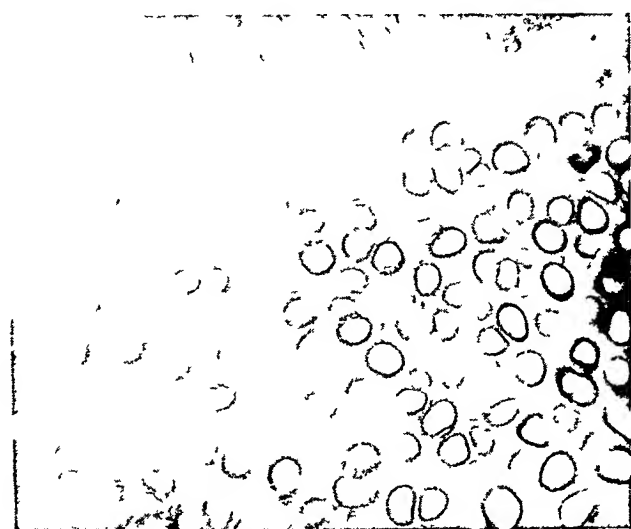


FIG 3—Experimental rabbit ear cartilage after six months' heterogenous transplantation

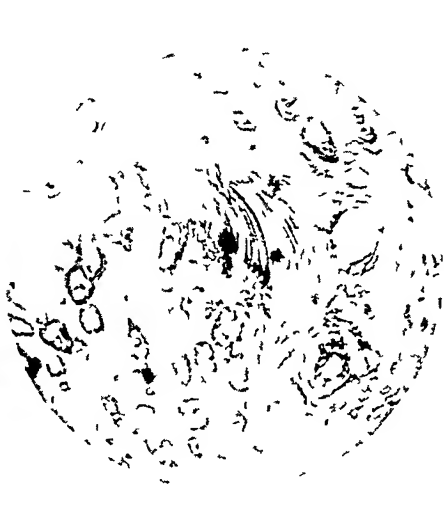


FIG 4—Preserved rib cartilage after two years' transplantation

tions to be determined in the affirmative, establishing the fact that heterogenous cartilage grafts remain as cartilage, the cartilage retaining its form even though cellular death has occurred.

Shortly after this an ear cartilage was removed from a person soon after death and transplanted into the abdominal wall of another individual, with the

idea of employing it later to reconstruct an ear. One year later this cartilage was distinctly palpable under the skin, but unfortunately the patient drifted away and it was never possible to obtain microscopic sections of it or to complete the reconstruction. About this time the author became acquainted with the splendid work being done by O'Connor and Pierce¹ on preserving excess

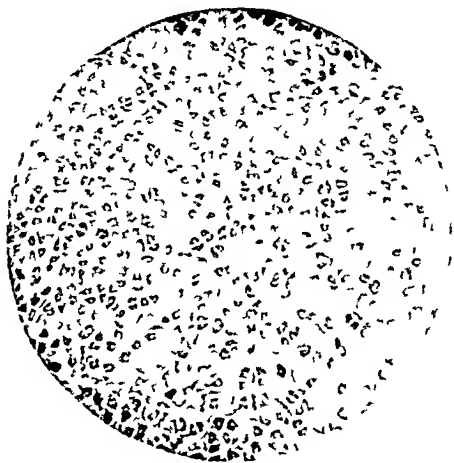


FIG 5—Preserved ear cartilage after two years transplantation

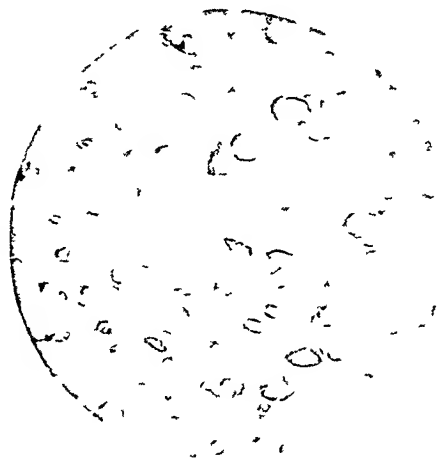


FIG 6—Preserved ear cartilage after four years' transplantation

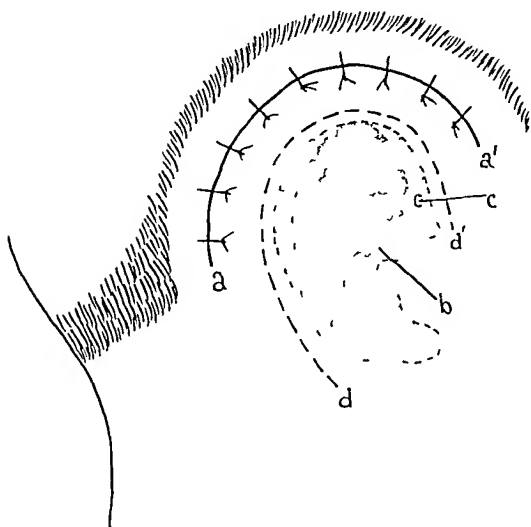


FIG 7—Shows implantation of preserved cartilage (a a) Represents incision in the hair line (b) Shows ear cartilage placed under skin flap (c) Represents puncture holes through the cartilage for anchorage (d d') Shows line of incision for the second stage operation

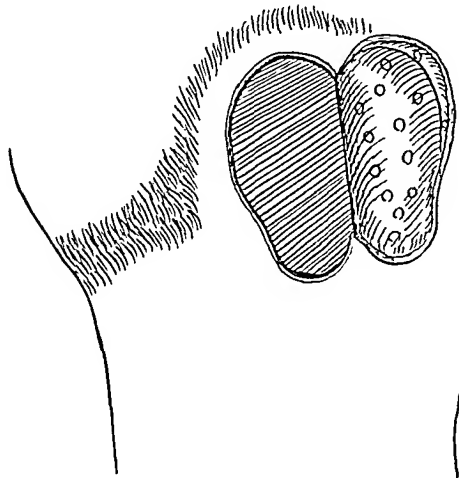


FIG 8—Shows the implanted cartilage with its skin covering raised and brought forward leaving a raw surface behind the new ear and over the mastoid region. This is covered with a free stent skin graft

rib cartilage indefinitely, and its satisfactory employment in various reconstructive procedures, and all credit should be given them for the valuable adjunct to plastic surgery this procedure has advanced. Since their work, not only experimentally but clinically, has shown that the employment of preserved rib cartilage is practicable, why should not the same hold true of

RECONSTRUCTION OF EAR

ear cartilage? Clinical experience has shown that ear cartilage behaves in the same manner, and thus it can be collected, preserved and stored for future use, and employed as a scaffold upon which to build a new ear. Pierce and O'Connor have found the most satisfactory preservative to be a solution of

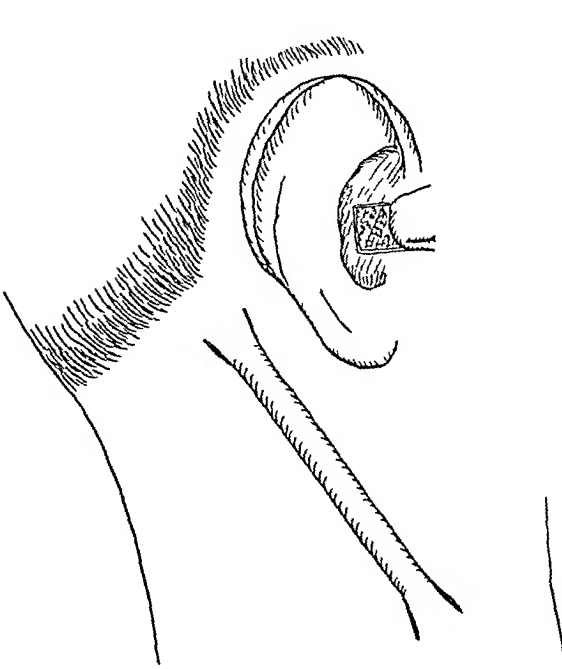


FIG. 9—Double pedicle tube flap of the neck. At the same time a flap of skin is turned on itself to form the new tragus which procedure deepens the daum and concha. The resulting raw area is covered with a free skin graft.

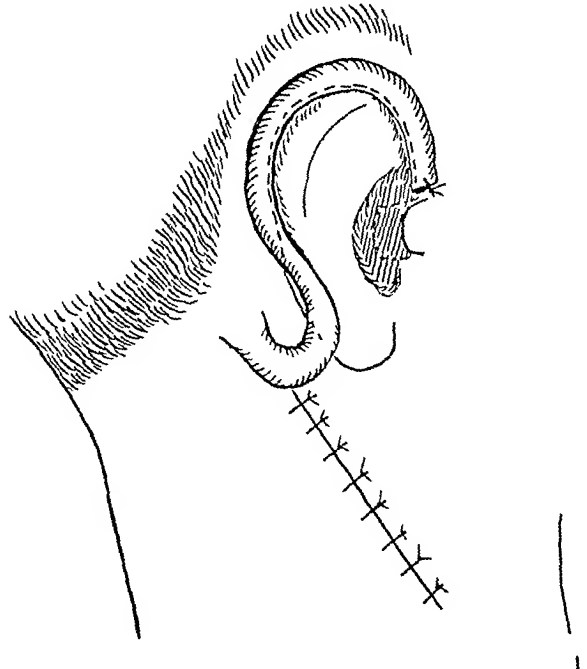


FIG. 10—Lower end of tubed pedicle raised, and attached to crus of helix. Tube opened and draped over the ear to form the helix.



FIG. 11—Subtotal loss of ear due to automobile injury.



FIG. 12—Preserved ear cartilage transplanted in the mastoid region.

aqueous merthiolate in normal saline, 1:4, and kept on ice. The solution, however, should be changed about every week or ten days.

In the employment of ear cartilages from cadavers, it is found that they are often too soft and pliable, but this can be overcome by soaking for two or three days in a solution of formalin before being placed in the merthiolate

This method is also applicable in the case of automobile or other injuries where part of the ear is completely severed and the piece can be found. In these instances the skin is removed and the cartilage stored in the usual manner until such time as the ear reconstruction is deemed advisable. Since

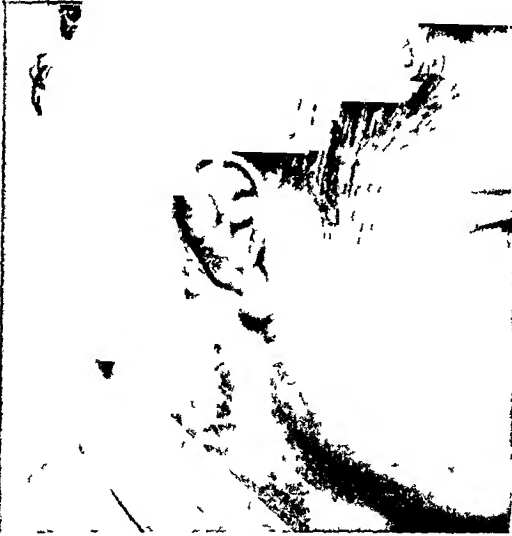


FIG 13—The ear brought forward and the back of the ear and mastoid covered with a stent free graft



FIG 14—Double pedicle tube flap raised from the neck

these cartilages are essentially foreign bodies, and consequently may become loose from the surrounding tissue, it has been found that perforating the cartilage with small holes before it is planted allows granulation tissue from



FIG 15—Tube flap transferred to the edge of the new ear



FIG 16—Tube flap molded to form the new helix

both sides to pass through the perforations, and in this way acting as rivets to hold the cartilage in place

The reconstruction of the ear is accomplished in about five stages. At the first stage the cartilage, which has been previously perforated, is planted

under the skin of the mastoid area through a curved incision high up in the hair line. In about two months the cartilage, with the skin of the mastoid region, is raised, thus bringing the new ear forward, leaving a raw surface over the mastoid and back of the new ear. This area is covered with a thin split-graft placed on a molded stent. At a later date a double pedicle tube-flap is made on the neck, about the size of a lead pencil, and long enough to be carried over the ear. In about three weeks the lower end of the flap is transferred to the edge of the new ear, and in three more weeks the draping of the flap around the new ear to form the helix is completed, and the excess removed or returned to its bed. If no tragus exists this can be constructed by infolding a flap of skin on itself and the resulting raw area covered by a free graft, and this procedure at the same time deepens the concha.

Having employed this method in ear reconstruction during the past few years, in only one has there been a loss of the cartilage, and this resulted from an infection in the graft bed which might have occurred by the use of an autogenous graft. It is believed that ears so reconstructed, with a normal ear scaffold, are more sightly and satisfactory to the patient and surgeon alike.

REFERENCE

- ¹ O'Connor, G. B., and Pierce, G. W. Refrigerated Cartilage Isografts. *Surg., Gynec., and Obstet.*, 67, 796-798, December, 1938.

DISCUSSION—DR VILRAY P. BLAIR (St. Louis, Mo.) No one who has never tried to make an ear can appreciate the value of this contribution. We have attempted many of them in some other way, and our results recommend this method most strongly. In using a shell of cartilage of somewhat the size and shape desired, cut from the surface of the anterior costal junctions, you can make something that will stand out, give it the general outline of an ear, and in this way get by, because nobody looks at an ear, but will note its absence four blocks away. Another thing that makes this timely is that, until recently, we were never called upon to restore a girl's ears, but they are now exposing these last of hidden things. I think one point is worthy of discussion. Possibly the outstanding contribution of the paper is the removal of a piece of live cartilage from a dead body before changes have occurred, and then burying it in the abdominal wall of the patient who is going to be the recipient. That would give you time to study the recipient's tissue reactions. A suggestion along this line has been made by Gillies—that is, to dissect out the mother's cartilage and use it as the form upon which to build the child's ear. I was more impressed with this suggestion after seeing some patients of Dr. Paul K. Greeley's, in Chicago, upon whom he was carrying out this plan. There is probably no advantage in using the mother's cartilage other than that it is available. One thing I noted in the mother was that there was little deformity after removing the cartilage, merely a little lopping over of the ear, and that can be taken care of by slipping in a little bit of her costal cartilage. One tremendous advantage in using human ear cartilage is that it permits early restoration. A great deal of psychic damage can be done by having a child teased about the deformity. No matter what cartilage is used, if you can put it over, I should say it probably should be done before the age of five, and that is a tremendous advantage.

Doctor Pierce and Doctor O'Connor did a good deal of work with preserved costal cartilage.

DR JOHN STAIGL DAVIS (Baltimore, Md) I have been much interested in Doctor Kirkham's report I have been using cartilage transplants for a great many years, and recently have gone back to trying isocartilage again My feeling is that if it is possible to obtain autogenous cartilage I think it ought to be used The difficulty with isocartilage, which has been preserved, is that you never know when the reconstruction, which you have built with the preserved cartilage, will begin to absorb Some of the transplants last over long periods of time, and others absorb quite quickly I seldom use large pieces of preserved cartilage, but have found it useful for filling out small areas I prefer, in reconstructive work, autogenous cartilage which is fresh, or has been stored under the skin for as long as it is convenient

DR H L D KIRKHAM (Houston, Texas), closing I want to thank Doctor Blain and Doctor Davis for this discussion Undoubtedly the use of fresh cartilage is very much superior, where it can be obtained, to the use of any preserved cartilage Also, if you get fresh cartilage from a body that has just died, as we did in our first experimental work and in the first case with the child, that would be preferable, but the objection is that whenever you have an ear to reconstruct such cartilage is seldom available Another objection to fresh cartilage is that when you put the fresh cartilage under the skin, and it is later taken out, it has become attached to the surrounding tissue and you have a piece of thick fibrous tissue—scar tissue which has thickened up—and I do not think you get such a thin ear in the final result

MEMOIRS

WILLIAM THOMAS BLACK

1875-1938

THE LIFE of Dr. William Thomas Black, which began in Stanton, Tennessee, January 13, 1875, came to a close in Memphis, Tennessee, December 10, 1938. His passing was sudden, the result of a heart attack during the performance of an operation, thus, it was granted to him to pursue to his last hour the work he loved so well.



WILLIAM THOMAS BLACK, M.D.

Doctor Black's early education was received in public schools, and his premedical training from private tutors. He obtained his degree in medicine from the Memphis Hospital Medical College, later the University of Tennessee Medical College, in 1898, and following his internship, attended surgical clinics in Philadelphia, New York, Boston and Chicago.

At the beginning of his career, Doctor Black practiced general surgery for several years, and in this field achieved an enviable reputation. His real

interest, however, was in gynecology, and he, therefore, gradually abandoned general surgery in favor of this specialty. Through his intense devotion to his work, his capacity for painstaking research, and his numerous writings, he was soon recognized as one of the leading gynecologists of the country, and accordingly was the recipient of many honors. His professional affiliations included memberships in the American College of Surgeons, the American Board of Obstetrics and Gynecology, the American Association of Obstetricians and Gynecologists, the Southeastern Surgical Congress, the Central Association of Obstetricians and Gynecologists, the Tennessee State Medical Association, and the Southern Surgical Association. Of the last three, he had in former years held the office of Vice-President. He also organized and was the first Chairman of the Section on Gynecology of the Southern Medical Association. Doctor Black was a popular speaker at medical meetings, his papers were always stimulating and informative, displaying a complete grasp of his subject.

Soon after the completion of his medical training, Doctor Black was made a member of the faculty of his alma mater. He served faithfully in this capacity for more than 30 years, taking an active part in the affairs of the institution both before and after its absorption by the University of Tennessee, and progressing from one appointment to another. Several years before his death he was elected Chief of the Department of Gynecology of the university. With this appointment, he also became Chief of the Department of Gynecology at the John Gaston Hospital. In addition, he was visiting gynecologist to the Baptist Memorial Hospital, consulting gynecologist to St. Joseph's Hospital, and visiting gynecologist to the Shelby County Almshouse.

We who knew Doctor Black best remember him best as a confrere, thorough in investigation, conservative in judgment, conscientious in counsel, and skillful in the practice of his art. If one should be called upon to name his most outstanding characteristic, however, one would probably say it was his conscientiousness in all matters pertaining to his work. He was keenly aware of his obligations as an instructor at the university, throughout the years never failing to appear in the classroom and clinic except under the most urgent circumstances, and always bringing to his teaching the same interest and thoroughness which he exhibited in his other professional activities. Also, in all his ministrations to his patients, he was guided by a profound sense of responsibility, advising according to his best judgment and rendering service to rich and poor alike, regardless of the cost to himself.

We cannot recall that Doctor Black had any particular hobbies. He was fond of hunting and fishing, but seldom took occasion to indulge in these pleasures. Rather, so absorbed was he in his work that he spent most of his vacations in some endeavor connected with the profession.

In looking back over a long acquaintanceship with Doctor Black, it is pleasant to dwell upon those hours of relaxation when, after a meeting, across the luncheon table, or at some social function, we had the privilege of enjoying his genial companionship and his entertaining conversation. He was the

fortunate possessor of a most engaging personality, which made his presence welcome in any gathering

Doctor Black was married in 1902 to Floia May Grehan, of Appleton, Wisconsin. She, with two daughters and one son, Dr. William Thomas Black, Jr., survive him. In his going, they lost a devoted husband and father, his friends lost a delightful companion, and the profession lost an able and respected member, a worthy exponent of its best traditions.

ROBERT L. SANDERS

FRANCIS HENRY HAGAMAN

1896-1939

THE SUDDEN DEATH of Dr Francis Henry Hagaman in an automobile accident on the morning of August 19, 1939, while he was hurrying to the



FRANCIS HENRY HAGAMAN, M.D.

bedside of a patient, was a deplorable loss to American Surgery That it occurred during the performance of duty to the suffering was in keeping

with the selfless devotion of Doctor Hagaman to the relief of human pain, the alleviation of human sorrow. The keynote of his character was duty to men and to his Divine Maker. But his feeling went beyond the dictates of duty, it extended through gentlest consideration to deep and tender love. To noteworthy skill as a surgeon, he added that crowning achievement of character—heartfelt sympathy, the precious balm for all wounds, whether of body or of spirit.

Doctor Hagaman was of the notable Dutch stock that emigrated from Holland to New York in the early days of American history and that has furnished our country so many of its admirable citizens. The original Hagamans came to the colony of New Amsterdam about 1650, later descendants of the family moved to Somerset County, New Jersey, settling near Flemington. In subsequent times, a branch of the Hagamans came South, selecting as their home Centreville, Mississippi, where, on August 19, 1896, the subject of this memoir was born, the eldest of the four children of Dr. R. L. Hagaman and his wife Vernon Darden Hagaman, his sire contributing to his son a passion for service to humanity through the profession of medicine.

He attended the grammar and high schools of Centreville, from which he was graduated in 1911. He spent the academic year of 1912-1913 in attendance at the College of Arts and Sciences, Tulane University, where his study was devoted to premedical work. During the summer of 1913 he took a business course. After its completion he worked as a clerk for the Cori-Williams Tobacco Company, Jackson, Mississippi, until the fall of 1914. He then entered the Tennessee College of Medicine at Memphis, where, in 1916, he completed the first two years of the medical course. From 1916 to 1918, he studied in the Medical College of Tulane University, from which he was graduated with the degree of Doctor of Medicine on June 5, 1918.

On July 12, 1918, he enrolled for Naval Service at Raymond, Mississippi, and served as Lieutenant, Junior Grade, Medical Corps, U. S. Navy. His active duty dated from November 6, 1918, to December 15, 1919, when he was honorably discharged. The period of his active duty was partly spent at Washington, D. C., where he was attached to the Naval Medical School during the influenza epidemic of 1918. At the time of his discharge he was stationed at the Naval Hospital, Gulfport, Mississippi, but was enrolled in the Naval Reserve Force until September 30, 1921.

In January, 1920, he took up the general practice of medicine in Sardis, Mississippi. On October 31, 1920, he was married to Edwina Short at Centenary Methodist Church, St. Louis, Missouri. Her wit and charm constituted for him a never failing source of happiness.

He served as Assistant Superintendent of Mississippi Charity Hospital, Jackson, Mississippi, from January, 1922, to March, 1925, when he went to New York City, where he served as a resident in the Hospital for Ruptured and Crippled Children. There he came under the influence of Dr. Royal Whitman, whose famous technic he admiringly adopted as a model in his own subsequent practice. In May, 1926, he returned to Jackson, Mississippi,

where on July 1, 1926, he formed a partnership with Dr H R Shands, a connection which was continued until his death. He was elected to membership in the Southern Surgical Association in 1936.

He is survived by his widow and by a son of 17, who gives every promise of worthily emulating the character of his lamented father.

The tragic taking-off of Dr Hagaman at the early age of 43, prevented the harvest of a widespread fame that would have resulted, in due time, from a more extended recognition of his skill, expertness, and versatility in the varied fields of surgery to which he devoted himself with untiring application and ceaseless energy. His main interest at the end, as at the beginning, of his practice was in orthopedics, in which branch of work he had no superior in the state of Mississippi. The most precious dream of his life was to render the utmost possible service to crippled children. His successful treatment of them, during the decade of his connection with the Mississippi Baptist Hospital at Jackson, contributed not only immeasurable benefit to his patients but also illuminating inspiration to the members of the profession.

To provide the needed recreation of physical strength strained by arduous devotion to his labors, he adopted as his hobbies photography and horseback riding. In both of these he became, for an amateur, exceptionally accomplished, so deeply ingrained was thoroughness as an element of his character.

The untimely demise of Doctor Hagaman bereaves the profession of surgery of a skilled, conscientious, scientific practitioner, the State of Mississippi, of an estimable citizen, his church, the Presbyterian, of a faithful parishioner, his family, of a dearly beloved husband and father, and the Association, of a most worthy member—trueless, patient, skilled surgeon that he was, friend to all living things, a servant of life itself. Need more be said?

HARLEY R SHANDS

REGINALD H JACKSON

1876-1939

IN THE DEATH of Reginald H Jackson, the medical profession lost one of its most distinguished members, and Wisconsin one of its most revered



REGINALD H JACKSON, M D

citizens Doctor Jackson possessed, to an unusual degree, those qualities of mind and heart that endeared him to all those with whom he came in contact

Perhaps his outstanding characteristic was the tenderness with which he approached his surgical duties

He despised mediocrity and never tired in his quest for knowledge, yet his greatest joy was the alleviation of the suffering of his patients. Doctor "Reg," as he was fondly called by his friends, was always a true and loyal friend, a counselor, a student as well as a teacher. He was a great student of pathology and always insisted on a personal study of the gross and microscopic specimen on the completion of an operation. At the operating table, he insisted that tissues be handled with extreme gentleness and care.

Perhaps his outstanding professional attainment lay in the originality of his contributions to both the fields of medicine and surgery. His keen diagnostic sense was always the last court of appeal for his associates. As such, he inspired the highest confidence in all who knew him.

Doctor Jackson was keenly interested in the betterment of the medical profession and always supported its highest ideals. He made numerous contributions to the medical literature and the many scientific papers he presented to the various medical societies are evidence of his intense interest in his work. He was a member of his County and State Medical Associations, serving as president of the Wisconsin Medical Society in 1933, American Medical Association, the Southern Surgical Association, the Western Surgical Association, of which he was president in 1935, and of the American College of Surgeons.

Reginald Henry Jackson was born January 17, 1876, in De Pere, Wisconsin, and was the third generation of surgeons in his family. His father, the late Dr. James A. Jackson, and his grandfather, Dr. Joseph Hobbins, came to Madison from England in 1853. His mother was Josephine Hobbins Jackson.

When Doctor Jackson was a small child, his family moved to Madison where he had since made his home. He began in his youth to work with his father, then one of the pioneer surgeons of Wisconsin.

After completing his academic studies at the University of Wisconsin, Doctor Jackson went for his medical training to the College of Physicians and Surgeons at Columbia University, New York City. After his internship he became house surgeon at the Presbyterian Hospital in New York. After his return to Madison, he became impressed with the clinic idea and with his father and brothers, James and Arnold founded the Jackson Clinic. He served as head of the Clinic and was Chief-of-Staff of the Methodist Hospital until the time of his death.

Doctor Jackson married Elizabeth Biese Stevens, June 4, 1908. Their only child, Dr. Reginald Jackson, Jr., had for the past three years been his father's assistant and is continuing on the staff where his father served so skillfully and with such tireless energy and idealism.

ROBERT L. PAYNE

WILLIAM BATTLE MALONE

1874-1939

WILLIAM BATTLE MALONE, a Fellow of the Southern Surgical Association since 1916, and Vice-President in 1923, was born July 4, 1874, at Browns-



WILLIAM BATTLE MALONE, M.D.

ville, Tennessee, and died on September 4, 1939, at Memphis, Tennessee

After graduation from Webb's Preparatory School at Bell Buckle, Tennessee, he completed the classical course at Vanderbilt University, receiving

the A B degree, *cum laude*, in 1896, and the M D degree from the University of Tennessee College of Medicine, in 1899

After serving his internship in New York, in 1900, he returned to Memphis and became associated with the late Dr William B Rogers, a distinguished teacher of surgery of that period, who exerted a profound and lasting influence upon his students and whose mantle fell upon the shoulders of Doctor Malone, who succeeded him as Professor of Surgery in the University of Tennessee College of Medicine, in 1913. He was a most worthy successor and disciple of this great surgical pioneer, carrying on his high concepts of professional duty and skill which mark, always, the Master Surgeon.

At the outbreak of World War, Doctor Malone was commissioned Major in the Medical Corps of the Army. Serving overseas with the A E F, he was awarded the Distinguished Service Medal "for exceptionally meritorious and distinguished services as chief of surgical teams in hospital formations at the front through all combat activities of the American Expeditionary Forces from the Cantigny offensive to the close of the Meuse-Argonne offensive."

Always a leader in organized medicine, giving freely of his time and talents, Doctor Malone was a past president of the Memphis and Shelby County Medical Society, a past president of the Tennessee State Medical Society (1928), a past president of the American Association of Railway Surgeons (1917), a Fellow of the American College of Surgeons, and Vice-President of the Southern Surgical Association (1923).

Long will he be remembered and revered because of his contribution to the organization and development of the Methodist Hospital, of which he was Chief-of-Staff from its founding in 1921. To those of his confreres who knew him, the Methodist Hospital will always be a memorial to his genius and an expression of his love for suffering humanity.

William Battle Malone, to the manor born, represented all that was ethical in the profession—kindly, loyal and honest. Loved by those who were privileged to know him well, respected by all for his sterling traits of character, a gentleman and Master Surgeon, his like will not pass this way again soon.

Well may it be said of him

"His life was gentle, and the elements
So mix'd in him that Nature might stand up
And say to all the world, *This was a man!*"

JOHN LUCIUS MCGHEE

EDITORIAL ADDRESS

Original typed manuscripts and illustrations submitted to this Journal should be forwarded prepaid, at the author's risk, to the Chairman of the Editorial Board of the ANNALS OF SURGERY

Walter Estell Lee, M D
1833 Pine Street, Philadelphia, Pa

Contributions in a foreign language when accepted will be translated and published in English

Exchanges and Books for Review should be sent to James T Pilcher, M D, Managing Editor, 121 Gates Avenue, Brooklyn, N Y

Subscriptions, advertising and all business communications should be addressed

ANNALS OF SURGERY
227 South Sixth Street, Philadelphia, Pa

ABSTRACTS OF PAPERS OF THE 1940 MEETING OF THE AMERICAN SURGICAL ASSOCIATION

SYMPOSIUM

FLUID AND ELECTROLYTE NEEDS OF THE SURGICAL PATIENT

THE STRUCTURE OF THE BLOOD IN RELATION TO SURGICAL PROBLEMS

John P. Peters, M.D. (by invitation) The proper conduct of the physiological processes of the body requires that the composition as well as the volume of the fluids in the body be maintained. The components that require the greatest consideration are the salts, which maintain the osmotic pressure and determine the distribution of water between cells and the interstitial fluids. Operative procedures are peculiarly prone to disturb water and salt relations and therapeutic efforts have often enough not been directed towards the restoration of natural conditions. Too much emphasis has been laid upon the restoration of fluid volume rather than composition, and often salt depletion has been exaggerated by methods that wash salt from the body and administration of excessive quantities of fluids without salt. The nutrition of the patient is too often neglected with the result that patients develop protein deficiencies which lead to edema. Case reports will be used to illustrate these errors and also to outline methods of treatment by which they may be avoided.

THE PRESERVATION OF BLOOD

David C. Bull, M.D. (by invitation) and Charles R. Drew, M.D. (by invitation) The intelligent use of preserved blood requires knowledge as to wherein and to what extent it differs from fresh blood. To this end certain observations have been made on the changes taking place in the cells and the electrolytes. The white cell and platelet counts fall 50 per cent or more in the first two or three days but the erythrocyte count remains little changed for a month though the individual cell shrinks and much of its hemoglobin is to be found in the plasma. An important factor in the degeneration of the cells is their loss of potassium by diffusion into the serum. This phenomenon is hastened by trauma but is little influenced by the type of preservative or container. Though the plasma potassium rises as much as tenfold and potassium is definitely a toxic substance, the transfusion of preserved blood should be safe on this score except perhaps when large amounts of blood are given rapidly in conditions involving hyperkalemia. The variations in the other electrolytes are of interest physiochemically rather than clinically.

THE PLASMA PROTEINS OF PRESERVED BLOOD

John Scudder, M.D. (by invitation) Factors governing the cellular elements, electrolytes, hydrogen ion concentration, lactic acid, and blood sugar in preserved blood have been investigated. This communication deals with the proteins. In plasma there are five main proteins: albumin, alpha, beta, and gamma globulin, and fibrinogen. Their total concentration amounts to around seven per cent. Citrated blood was stored for

varying lengths of time in a refrigerator. Samples of the plasma were removed and after dilution and dialysis for 48 hours were placed in a Tiselius apparatus. As the different components of the plasma move with different speeds when subject to an electric current, a photograph may be taken showing these different proteins. From these pictures the total as well as the individual amounts of the different proteins may be obtained. Certain preliminary remarks may be made. Post mortem plasma is definitely abnormal. Lyophilized serum under the present methods of manufacture, reveals certain disturbances. Plasma from normal individuals when stored in proper shaped flasks and kept in an ice box, shows less denaturation than when stored in large flasks at room temperature. Reactions in plasma transfusion may be minimized by giving heed to these simple precautions.

SODIUM CHLORIDE METABOLISM OF SURGICAL PATIENTS

Walter G. Maddock, M.D. (by invitation). Disease of or operations upon the alimentary tract often interfere with the normal intake of sodium chloride, and at the same time may cause abnormal losses of this important electrolyte. The need for replacing these losses has been well established and is better carried out with a knowledge of sodium chloride metabolism. Facts pertinent to the simple handling of this problem in surgical patients are presented.

LOSS OF FLUID AND SALT ASSOCIATED WITH SUCTION DRAINAGE OF THE GASTRO-INTESTINAL TRACT

Grover C. Penberthy, M.D., and (by invitation) J. Logan Irvin, Ph.D., and R. Mayo Tenery, M.D. The importance of supplying sufficient fluid, electrolyte and nutrition to patients during suction drainage applied to the gastrointestinal tract has been frequently stressed. The difficulty of supplying adequate fluids, salt and food by the oral route to patients with a tube draining the stomach or duodenum is self evident and in addition the loss of fluid and salt from aspiration of stomach and duodenum makes adequate replacement by other routes important. The fluid lost through suction drainage at the ileum even when great, may be replaced through increase in the oral intake. Nutrition and fluid requirements can be maintained more easily, the lower the suction is applied. Regardless of the position of the tube during suction drainage, adequate intake output studies are important to prevent dehydration. The regulation of intake to meet body needs through hunger and thirst is more likely in the case of drainage from the ileum than from the duodenum.

PLASMA LOSS IN ACUTE INTESTINAL OBSTRUCTION

Jacob Fine, M.D. (by invitation). Continuous distention of the small intestine in the dog produces a fatal loss of plasma volume. Studies on the mechanism involved show (1) that this is a phenomenon specific to the small intestine and does not occur when the colon, gall bladder and other hollow organs are distended, (2) that it is not due to dehydration, (3) that it is not due to distention of the peritoneal cavity, since short distended loops also produce a marked fall in plasma volume. Decompression of the intestine stops the loss of plasma and facilitates its return to the circulating blood. Desoxycorticosterone also inhibits the loss of plasma due to distention of the small intestine. Preliminary clinical studies confirming some of the above observations have been made. Experimental studies will be presented dealing with the effect on plasma volume of extraperitonealizing the distended intestine and of excluding the circulation of the intestine from the general circulation.

PLASMA LOSS IN SHOCK AS EFFECTED BY THERAPY

A S Minot, Ph D (by invitation) Consideration of not only the quantity of fluids lost but also of the quantity and type of electrolytes lost with fluid in a given patient is necessary for successful replacement therapy Too rapid or too liberal administration of fluid and electrolytes may lead to complications which at times are as serious as those which arise from failure to supply them in sufficient quantity In patients in a poor state of nutrition or in whom there is either localized or general injury to capillaries, it is particularly difficult to maintain the proper distribution of administered fluid Massive edema may occur while the blood stream remains dehydrated or even becomes progressively more dehydrated Under these conditions the administration of colloid is an indispensable factor in the restoration of fluid and electrolyte equilibrium

HYPOPROTEINEMIA AND ITS RELATION TO SURGICAL PROBLEMS

I S Ravdin, M D The serum proteins are the major factor in keeping fluids in blood vessels Too much attention has been paid to the administration of water and salts and not enough to the forces that keep these in blood vessels Certain profound biological effects may occur as the result of hypoproteinemia Hypoproteinemia, resulting in gastrointestinal edema, retards gastrointestinal motility The edema may cause such retardation of emptying of the stomach at the site of a new anastomosis as to mimic in every way a technical defect of the operation It also increases the period of delay in wound healing and thus may be a factor in wound disruption It is important that the labile stores of protein in the body be maintained An adequate amount of protein in the diet prior to operation will reduce the incidence of injury to the liver following the use of volatile anesthetics The susceptibility of the liver to injury may be profoundly influenced by diet Adequate protein in the diet is important in conditioning the liver for minimal injury The parenteral administration of amino acids has not corrected hypoproteinemia in our cases The importance of gastrointestinal feeding in the presence of nutritional deficiency will be pointed out

FLUID AND NUTRITION MAINTENANCE BY THE USE OF AN INTESTINAL TUBE

W Osler Abbott, M D (by invitation) For the average surgical patient the problem of preserving the fluid and electrolyte balance is relatively simple The cases of chronic gastrointestinal disease requiring operative relief are more difficult to manage because of the starvation which is often present, not only for a variable time before operation, but often for some days thereafter While this can be remedied to a degree by parenterally administered solutions we believe that in the presence of pyloric obstruction, jejunal feeding is often preferable We have, therefore, used a double lumen tube passed through the newly formed stroma One lumen is used for keeping the stomach empty, the other for the intra intestinal administration of food In conditions leading to obstruction further down the tract a long intestinal tube, by emptying the gut contents down to lesion allows the oral administration of a balanced fluid electrolyte and fluid intake

PARENTERAL PROTEIN REPLACEMENT WITH AMINO-ACIDS

Robert Elman, M D Various types of patients suffering protein deficiency and unable to ingest sufficient protein nourishment by mouth have been treated by the intravenous injection of fluid containing electrolyte glucose, and amino acids The amino acids were obtained by the enzymatic hydrolysis of casein Nitrogen balance has been achieved with regularity indicating utilization of the injected nitrogen Evidence of serum albumin regeneration has also been noted in a few cases Improvement in the general

clinical picture has also been observed. A few of the problems involved in intravenous protein administration by this method have been discussed.

THE RATION OF PROPER PREPARATION OF SOLUTIONS FOR INTRAVENOUS THERAPY TO ALLERGIC AND FEVER REACTIONS

Cutl W. Walter, MD (by invitation) Hospitals responsible for the maintenance of a major operating room are capable of preparing a safe supply of parenteral fluids economically. A technic insuring chemical purity of the product as it flows from the injecting needle is the only essential for success. This involves a source of freshly distilled water having a maximum volume conductivity (20° C) of 2.0×10^{-6} mhos, a supply of chemically pure electrolytes and dextrose, an easy method of mechanically cleansing the inner surface of glassware, tubing and needles, and simple apparatus for mixing, sterilizing, storing and dispensing the fluids. Confusion of the meaning of the terms "chemically pure" and "sterile" most frequently accounts for failure. A standardized technic proven practical and safe in 250 hospitals will be demonstrated.

THE QUESTION OF DRAINAGE FOLLOWING CHOLECYSTECTOMY

Irvin Abell, MD, and (by invitation) Irvin Abell, Jr., MD. At present a review of a series of 500 consecutive operations is being made with an idea of determining what in our practice, has constituted the indications for the employment of drainage and for the cases in which no drainage has been employed.

PHYSIOLOGICAL FACTORS REGULATING THE LEVEL OF THE PLASMA PROTHROMBIN

Jonathan E. Rhoads, MD, by invitation of Walter E. Lee, MD. The rapid purification and synthesis of vitamin K and certain chemical substances with vitamin K activity have made it possible to test the limits of the effectiveness of vitamin therapy in combating prothrombin deficiency. The results obtained with several of these substances will be presented. In this series about 15 per cent of the patients failed to respond to substances with K activity. It has been possible to show that liver damage per se can cause prothrombin deficiency and that in the experimental animal it is much easier to produce prothrombin deficiency by liver damage than by bile salt deprivation. Furthermore, such liver damage acts directly and not merely through interference with bile salt formation. This type of prothrombin deficiency in animals responds poorly or not at all to vitamin K. From this it has been predicted that failure of patients to respond to vitamin K therapy implies severe liver damage. Clinical evidence and autopsy material will be presented to show that this is actually the case. The management of prothrombin deficiencies that do not respond to vitamin K therapy by measures planned primarily to restore liver function will be discussed.

CHOLECYSTITIS AND CHOLELITHIASIS PRODUCED EXPERIMENTALLY BY THE REFLEX OF PANCREATIC SECRETION

J. Dewey Bisgard, MD, and (by invitation) Charles P. Baker, MD. I have recently completed a series of studies in which I have produced acute and chronic cholecystitis and also bile pigment stones in experimental animals by causing pancreatic secretions to enter the gall bladder. This has been produced by a mechanism which is not only possible but also probable in man. I believe, therefore, that I have strong evidence in favor

of the theory of reflux of pancreatic secretions as an important etiological factor in the production of gall bladder disease. To my knowledge this is the first time that stones have been produced in experimental animals by the method of reflux. The work differs from that of Wolfer and others in that the reflux has been produced in a manner which is physiological and which could easily occur in man. I also have chemical and bacteriological studies of the gall bladder bile and histological studies of the gall bladder, liver, pancreas and kidneys. This experimental data is supported by observation of the presence of the pancreatic ferments in the gall bladder of a few patients with acute cholecystitis and other pertinent evidence.

ILEOSTOMY

Henry W. Cave, M.D., and (by invitation) Wm. F. Nickel, Jr., M.D. Surgical measures are being successfully carried out in an increasing number of patients suffering from intractable ulcerative colitis. As curative procedures appendectomy, cecostomy and colostomy have proven of no value, ileostomy alone in some instances has proven curative in certain stages of the disease. Questionnaires sent to various surgeons have resulted in obtaining interesting information. As the first stage of total colectomy it is invaluable in approximately 85 per cent of the patients operated upon. The type of ileostomy which has proven successful in our hands will be discussed. A detailed account of the care of ileostomy will be given. Many of these desperately ill patients when first seen are not good surgical risks even for ileostomy. Preoperative preparation will be discussed. In the acute fulminating, rapidly fatal form of the disease early deviation of the fecal stream by means of a double-barrelled ileostomy might prove advantageous. The technical pitfalls will be discussed.

THE DIAGNOSIS AND SURGICAL MANAGEMENT OF LEIOMYOMAS AND LEIOMYOSARCOMAS OF THE STOMACH

Frank H. Lahey, M.D. Because of the fact that leiomyomas occur as localized encapsulated growths tending to project into the gastric cavity they are apt to become ulcerated at their point of maximal projection. This not infrequently results in serious hematemesis. Because of these hemorrhages and the fact that the tumors cause digestive symptoms, these patients are often treated for peptic ulcer. Adequate x-ray examination readily reveals these lesions. From their tendency at first to be local and encapsulated their diagnosis is not difficult. Exclusive of hemorrhage in the leiomyomas with ulceration or central necrosis, they are chiefly dangerous because they are prone to sarcomatous degeneration. In certain cases as will be shown by removed specimens and roentgenograms it is possible to state with certainty that the lesion is benign. In others as will be shown by specimens and roentgenograms, it is possible to state that the lesion is definitely sarcomatous, but in an intermediate group it is impossible to settle preoperatively whether or not the lesion is sarcomatous. Of six patients with leiomyomas four showed sarcomatous degeneration. Because of this danger all leiomyomas of the stomach should be removed by subtotal gastrectomy in order to be certain that an adequate amount of stomach is removed should the pathological report prove to be sarcoma. These lesions have occurred as single leiomyomas, as single leiomyosarcomas and as multiple leiomyosarcomas involving the entire stomach. The patients have been treated surgically by subtotal gastrectomy and by total gastrectomy. There has been no mortality and a follow up of the cases is submitted.

ABDOMINAL NEOPLASMS OF NEUROGLIIC ORIGIN

Henry K. Ransom, M.D. A brief review of the incidence, distribution and pathology of the neurofibromata along with a discussion of their histogenesis and classification. A

group of 16 microscopically verified neurofibromata arising within the abdominal cavity is presented. These tumors may simulate a variety of lesions such as carcinoma of the stomach, colon or rectum as well as pancreatic cysts and retroperitoneal sarcoma. In the later stages, there may be serious complications such as intestinal obstruction, internal fistulae involving the intestine, colon, or bladder, and occasionally the tumors may undergo malignant degeneration. Some of these more unusual abdominal neoplasms which were originally regarded as sarcomas and myxomas have been reexamined and in the light of more recent knowledge, found to belong to the neurofibroma group. Detailed reports of certain illustrative cases are given, together with sketches, roentgenograms, photographs and follow up notes.

HEPARIN IN THE PREVENTION OF PERITONEAL ADHESIONS. REPORT OF PROGRESS

Edwin P. Lehman, M.D., and (by invitation) Floyd Boys, M.D. A preliminary experimental report on the use of heparin in the prevention of intraperitoneal adhesions (Lehman & Boys, *Annals of Surgery*, March, 1940) presented evidence that heparin introduced into the peritoneum was followed by the reformation of 25 percent of divided adhesions as compared with the reformation of approximately 150 percent of divided adhesions in various control groups. At the time of this report three out of 24 dogs had died of intraperitoneal hemorrhage and this occurrence was presented as a possible deterrent to clinical use of the method. The present report will present data on a series of experiments dealing with the danger of hemorrhage, with dosage and with methods of administration of heparin. Data on the relationship of heparin to contamination of the peritoneum and on the effect on adhesions of general, as opposed to local, heparinization will also be presented.

THE PREVENTION OF ISCHEMIC GANGRENE FOLLOWING SURGICAL OPERATIONS UPON THE MAJOR PERIPHERAL ARTERIES BY CHEMICAL SECTION OF THE CERVICO-DORSAL AND LUMBAR SYMPATHETICS

Idys Mims Gage, M.D., (by invitation) and Alton Ochsner, M.D. The sudden occlusion of a major peripheral artery either by ligature or embolus results in ischemic gangrene, necessitating amputation of an extremity in a rather high percentage of cases. A comparison of the incidence of gangrene following surgical treatment of aneurisms, gunshot and stab wounds, and emboli of the major peripheral arteries is presented and discussed. The prevention of ischemic gangrene by preoperative development and postoperative maintenance of an adequate collateral circulation by chemical section of the regional sympathetics is advocated in all surgical operations upon the major peripheral arteries.

EXPERIMENTAL STUDIES ON THE OCCLUSION OF LARGE ARTERIES

Herman E. Pearce, M.D. There has never been a satisfactory method devised for the gradual occlusion of the great vessels. The original attempts to solve the problem were carried out by clamps, snares or bands placed on the outside of the artery. The constant force of the pulse against these occluding devices caused pressure atrophy and even rupture of the wall. It appears that any method dependent upon external pressure is dangerous. Several years ago attempts were made to gradually shut off the vessel by using internal occlusion from thrombosis. This principle is feasible but may be technically difficult in a deep wound because of the need of opening or puncturing the artery. Comment is made on some further studies with the use of this principle. A third method of attack might be to induce scar tissue contracture of the vascular wall.

and perivascular tissues Sclerosing agents, chemical irritants, large amounts of fascia and cellophane have been tested for this purpose The present report deals with the results of these studies on attempted gradual occlusion of the great vessels by the principle of scar tissue contracture in and about the vessel

ANEURYSM OF THE ABDOMINAL AORTA. SUCCESSFUL TREATMENT BY LIGATION

Daniel C Elkin, M D The abdominal aorta was first ligated by Astley Cooper in 1817 There are recorded some 25 similar operations since that time Most of these procedures have been carried out for iliac aneurysm It has been done nine times for aneurysm of the abdominal aorta, but has rarely been successful Matas' patient survived 17 months and Brooks' three Both died of conditions unrelated to the disease The patient here reported was operated upon June 1, 1939, for a large aneurysm of the abdominal aorta at the bifurcation Partial occlusion was obtained by two ligatures of cotton tape placed just above the aneurysm, which was undoubtedly due to arteriosclerotic changes in the aorta Calcification of the vessel made the placing of the ligature difficult and hazardous The patient had no disturbance of circulation of the extremities The aneurysm is now reduced to a small indurated mass without pulsation and is giving no symptoms Abdominal pain, which was severe, has disappeared The patient has returned to his duties as a country preacher and is able to be on his feet a greater part of the day and drives his car Various methods of ligating the aorta are discussed The history of previous cases is briefly reviewed with reproductions of illustrations of those of historical interest Collateral circulation to the extremities after ligation of the aorta is considered

CARDIO-VASCULAR SYMPTOMS PRESENTED BY PATIENTS HAVING CAVERNOUS HEMANGIOMATA AND VARICOSE VEINS

Walter E Lee, M D, and (by invitation) Norman E Freeman, M D Four patients with cavernous hemangiomata and varicose veins form the basis for the present report In three of these individuals the reflux of blood into the angiomas produced marked changes in the cardiovascular physiology Osteohypertrophy was the predominant feature in two patients In one individual, a defect in the lymphatic valves was also present which resulted in a chyliangioma of the scrotum and thigh Ligation of communicating veins with defective valves brought about relief of symptoms in three of the patients This symptom complex was first described by Klippel and Trenaunay in 1900 A similar condition was discussed by Parkes Weber in 1918 Sporadic reports of cases have appeared in the American literature

ARTERIOVENOUS FISTULA EXPERIMENTAL OBSERVATIONS AND A CRITICAL REVIEW OF EIGHTEEN CLINICAL CASES

Emile Holman, M D Observations made in a number of experimental animals, including three puppies, one puppy acting as a control and two puppies having had an arteriovenous fistula produced between the aorta and vena cava when three months old, and allowed to live for a year thereafter, these observations made upon the increased capacity of the vascular system in the presence of such a fistula, it being a new approach as to whether or not there is an increasing blood volume in the presence of a fistula We have demonstrated that there is a dilatation of the entire vascular system included in the short circuit, namely, heart, proximal arteries and proximal veins To fill this increased capacity there must of necessity be an increase in the blood volume as has proved to be the case in these puppies Other experimental observations have to do with the effect of this increased blood volume on the blood pressure and pulse, and the effect of the size of the fistula upon the subsequent sequence of events Pertinent observations in the clinical cases, covering these points, will also be reviewed Variations in the

cardiac size, following the establishment of the arteriovenous fistula will also be covered. In one clinical case we were fortunate enough to have accurate observations over a period of seven years, during which time repeated x-rays showed the gradual development of cardiac decompensation and its complete correction after the closure of a subclavian fistula.

RELATIVE LOCAL EFFICIENCY OF SULFANILAMIDE, SULAPYRIDINE AND SULFATHIOZOL IN CONTAMINATED WOUNDS

J. Albert Key, M.D., and (by invitation) Charles J. Frankel, M.D. Compound fractures of the ribs are produced in a series of laboratory animals. The wound is swabbed with a virulent culture of *Staphylococcus aureus*. Crystals of one of the above mentioned drugs are implanted in the wound and the wound is sutured. This work is now in progress and it is not possible at this time to state what the conclusions will be. Previous work by Jensen, Johnsrud and Nelson and by one of us has shown that the local implantation of sulfanilamide will prevent infection in most contaminated wounds. This has been proved clinically and experimentally. In the present paper we are merely endeavoring to determine whether or not either of the newer, and apparently most important additions to this series of drugs is more efficient than sulfanilamide in this respect.

THE RATE OF HEALING OF TENDONS: AN EXPERIMENTAL STUDY OF TENSILE STRENGTH

Michael L. Mason, M.D., and (by invitation) Harvey S. Allen, M.D. The flexor carpi ulnaris and extensor carpi radialis tendons in the dog have been divided and immediately sutured and a cast applied. At varying intervals following suture the tendons have been removed and the strength of union tested against a spring scale. It has been found that following an initial drop in tensile strength below the strength of the suture in fresh tendon, that there is a gradual increase in strength of union. This rate of increase, however, is subject to many variable factors prominent among which is that of function. A study has been made of the effect of various periods of immobilization upon the strength of the tendon at different periods in its healing process. Previous experiments have shown that there is considerable variation histologically between specimens of the same chronological stage in healing. These variations are probably due to technical operative difficulties, differences in activity of the animal after operation, infection, etc. and these factors must be evaluated in drawing any conclusions from tensile strength experiments. The results at present indicate that tendon healing follows the general laws of healing as determined by Carrel, Harvey, and others but that the rate of increase of strength of tendon is more rapid if some function is permitted toward the end of the period of fibroplasia. Certain results also appear to indicate that continuous immobilization beyond a certain period of time is associated with a reduction in tensile strength.

THE EFFECTS OF PRESSURE ON TISSUES: AN EXPERIMENTAL STUDY OF THE EFFECTS OF TEMPERATURE ON THE SURVIVAL OF ANEMIC TISSUES

Bunicy Brooks, M.D., and (by invitation) George W. Duncan, M.D. It is generally known that varying degrees of stress and strain exist in normal tissues and that unusual amounts of intermittent or constant pressure applied to tissues produce pathological changes. The effects of different amounts of pressure applied for different lengths of time upon the various tissues of the living animal are not definitely known. The tail of the rat is particularly well adapted for the experimental study of this problem, because the animal may be easily restrained and the tail contains so large a number of different

structures readily subjected to known pressures for measured lengths of time. In a series of experiments it was found that the amount of pressure and the length of time for producing massive necrosis were remarkably constant in healthy animals kept at ordinary room temperature. The pathological changes produced by amounts of pressure or periods of time short of that necessary for massive necrosis were also studied. Epithelial hyperplasia, fibrosing myositis and nerve degeneration were observed. Modification of the temperature of the tissues during periods subjected to pressure was found to be a powerful determinant of the length of time necessary for pressure to produce massive necrosis.

FURTHER ANESTHESIA STUDIES WITH PHOTOELECTRIC OXYHEMOGLOBINOGRAPH

Frank W. Hartman, M.D., (by invitation) and Roy D. McClure, M.D. Through the work of Kurt Kramer in 1933 and 1934, the measurement of oxyhemoglobin in the circulating blood was first accomplished. The Kramer method involves the isolation of an artery and the direct application of a photoelectric cell. The record is made by a galvanometer on photographic paper. Other investigators have shown that capillary blood may be used to determine oxygen saturation providing the capillary bed is first dilated with heat. The latter observation makes it possible to apply Kramer's principle and determine the oxygen saturation from a fold of skin. New photoelectric cells have been devised along with amplifying apparatus which allows the recording to be made with ink on a moving drum of paper. Prolonged observations with both the Kramer machine and our own apparatus are presented, showing the curves of oxygen saturation as produced by various sedatives and anesthetics in common use. Method of preventing and combating anoxia as well as its clinical measurement is discussed.

CONGENITAL PYLORIC STENOSIS

D. E. Robertson, M.D. This paper will review the result of about 450 cases of pyloric stenosis that have been treated by surgical operation at the Hospital for Sick Children, Toronto. It will compare the occurrence of these cases with those published where statistics are given as to sex and the relation to primogeniture. A special discussion is given to cases of twins. The technic of the Ramstedt operation is described in detail and moving pictures will be shown of the infants before, during and after operation in a pair of maternal twins.

GASTRIC ACIDITY BEFORE AND AFTER OPERATIVE PROCEDURE WITH SPECIAL REFERENCE TO THE ROLE OF THE PYLORUS AND ANTRUM. A PRELIMINARY REPORT OF A CLINICAL AND EXPERIMENTAL STUDY

Owen H. Wangensteen, M.D., and (by invitation) Richard L. Varco, M.D., Lyle Hay, M.D., Benedict Trach, M.D., and Stewart Walpole, M.D. Since 1906 when Edkins proposed the idea that the pyloric antrum played an important role in the regulation of gastric acidity, this hypothesis has been given wide credence by surgeons in the surgical management of ulcer. Considerable information, both experimental and clinical, is available to throw light upon the matter. Much of the testimony, both experimental and clinical, is in obvious disagreement with other available factual data. This paper essays to appraise critically the existing experimental and clinical literature upon the subject and to report the results of our studies. (1) In experimental animals with different forms of pouches and the influence of histamin and histamin free preparations upon gastric secretion. (2) Studies of pre and postoperative gastric acidity in patients.

with ulcer after various types of operation Finally, the results of studies in man on the nature of gastric secretion in man at night or during fasting periods

THE SURGICAL MANAGEMENT OF CARCINOMA OF THE LEFT HALF OF THE COLON

Howard C Naffziger, M D , and (by invitation) H Glenn Bell, M D For this study, 161 cases of carcinoma of the left half of the colon (exclusive of carcinoma of the rectum) were reviewed In only 74 of these was major surgery performed, the operability in the whole series was, therefore, 46 per cent In this analysis, attention is directed to the preparation of the patient before operation by general measures as well as by decompression of the bowel In addition, an attempt is made to evaluate different types of operation by means of the five year results obtained, and a detailed study of the deaths in the series is included

THE REPAIR OF INGUINAL HERNIA WITH TRANSPLANTATION OF THE CORD TO THE FEMORAL CANAL

Wm F MacFee, M D Exposure of the inguinal canal and excision of the hernial sac are done through the usual incision and in the usual manner The defect in the transversalis fascia is closed with interrupted sutures The upper and lower surfaces of the inguinal (Poupart's) ligament are dissected free of fat and fascia and the femoral canal is then laid open by detaching the inguinal ligament from its insertion in the pubic spine and freeing it along the superior pubic ramus until the femoral canal is entered The cord is then transferred from the inguinal canal to the femoral canal and the inguinal ligament is returned to its original position where it is made fast with silk sutures The ends of the sutures along the pubic ramus may be left long, rethreaded, and used to approximate the internal oblique muscle, to the inguinal ligament along its line of junction with the structures overlying the superior pubic ramus The external oblique is closed simply or by imbrication as a second layer over the inguinal canal The chief advantage of the procedure is that it permits complete closure of the inguinal canal without sacrificing the cord and testicle Since June, 1937 this operation has been employed in the repair of twenty five hernias, many of them recurrent or large hernias of unfavorable type The results appear to justify further trial of the method

MOTOR AND SENSORY INNERVATION OF THE COLON AND BLADDER

James C White, M D , and (by invitation) Max Verlot, M D , and Otto Ehrenthel, M D This report comprises the results of two years' investigation of physiological changes in the bladder and colon which follow disease, injury, or operative lesions of the brain, spinal cord, cauda equina, and pelvic nerves In addition to making cystometrograms, the responses of the colon to distention and its sensation have been investigated by a similar technic The normal colonmetrogram is very similar to the cystometrogram, except for the greater capacity of the colon The results obtained in the following conditions will be considered (1) Brain tumors (2) Transverse lesions of the spinal cord above the pelvic visceral centers (3) The destruction of sacral segments, cauda or pelvic nerves (4) Tabes dorsalis and combined system disease (5) Observations

THE PROBLEM OF PRODUCING COMPLETE AND LASTING SYMPATHETIC DENERVATION OF THE UPPER EXTREMITY BY PREGANGLIONIC SECTION

Reginald H Smithwick, M D Because we found the clinical results of postganglionic sympathetic denervation of the upper extremity to be unsatisfactory, and because we

found the results of preganglionic sympathetic denervation of the lower extremity to be satisfactory, we have been trying to develop a technic for preganglionic denervation of the upper extremity. In the past five years, three methods have been employed, first, ramisectomy (D2 and D3) and trunk section below D3. This was found unsatisfactory because it was often incomplete, and "relapse" of consequence due to regeneration frequently followed. Second, extraspinal anterior root section (D2 and D3) and trunk section below D3 was performed. This has always resulted in a denervation which was adequately complete, and in excellent immediate clinical results. In some instances, however, slight to moderate degrees of regeneration with partial return of symptoms has been noted months to years later. Our present technic, intraspinal (intraarachnoid) anterior root section (D2 and D3) and trunk section below D3, gives promise of being a satisfactory solution of the problem.



THE SURGICAL TREATMENT OF BRAIN ABSCESS BY EXPOSURE AND ENUCLEATION

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AND

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THE PROCEDURE of enucleation of an "encapsulated" brain abscess was considered, by Saigent,¹ to be the best method of treatment. He reported, in 1928, without giving details, five patients successfully treated in whom the abscess had been removed. More recently, Vincent² has renewed the interest in this method of treatment and has proved its value. Up to the present time, he has reported five patients. The abscess, in each instance, was exposed and removed without rupture. By our successful use of this method of treatment for brain abscess in six of seven patients, we wish to add further support to the procedure of complete enucleation, and from the experience gained, outline the surgical management of a patient in whom the diagnosis has been made.

Case 1*—Synopsis *Intracranial symptoms for six weeks. Signs of intracranial hypertension and bilateral sixth and seventh cranial nerve involvement. Ventriculogram. Lesion in right frontoparietal lobes. Craniotomy and complete removal without rupture of a walled abscess. Recovery.*

E. S., Hosp. No. 125122, female, age 20, was admitted to the Graduate Hospital, September 12, 1936, having been referred by Dr. J. C. Yaskin, Philadelphia, Pa. About three months prior to admission, the patient had had a tonsillectomy performed, under local anesthesia, without any untoward effects. Six weeks later she began complaining of headache and somewhat later of diplopia, loss of vision and vomiting. During the few days preceding admission to the hospital the pain in the head had become more severe.

Physical Examination—Temperature 99.3° F, pulse 64, respirations 22. Neurologically, she was mentally clear, had some rigidity of the neck, a bilateral Kernig, a bilateral papilledema of about three to four diopters, a cut in the left temporal field, weakness of both external recti muscles, more marked on the left than on the right, a paralysis of both seventh nerves, more marked on the right than on the left, and no significant changes in the extremities. The spinal fluid pressure was 350 mm. of water, and the spinal fluid showed five lymphocytes.

Submitted for publication June 8, 1939.

* Previously reported as Case 1, Brain Abscess of Undetermined Etiology, J. C. Yaskin, F. C. Grant, and R. A. Groff, *ANNALS OF SURGERY*, 107, 492, April, 1938.

The white blood count was 12,800, with a mild secondary anemia. The urinalysis was negative. The blood Wassermann was negative. The stools showed ova and segments of *Taenia saginata*, the patient's father recalled that she had had a tapeworm many years ago. Roentgenographic examination of the skull and the paranasal sinuses revealed no abnormalities. A second lumbar puncture revealed a pressure of 700 Mm of water, and the spinal fluid showed 15 cells.

Operation—September 19, 1936. Dr. F. C. Grant did a ventriculogram which showed a mass lesion on the right side, probably in the frontoparietal region. A right fronto-temporal bone flap was reflected. The dura was extremely tense, and upon its reflection, the sylvian fissure was seen to be pushed up by a mass beneath the surface and within the substance of the tip of the right temporal lobe (Fig. 1). A transcortical incision was made over the tumor which was removed without rupture. It measured $3\frac{1}{2} \times 4 \times 5$ cm.

Pathologic Examination—Section of the tumor revealed an abscess filled with a fibro-purulent, thick exudate. The wall was 0.5 cm thick. Microscopic examination of the

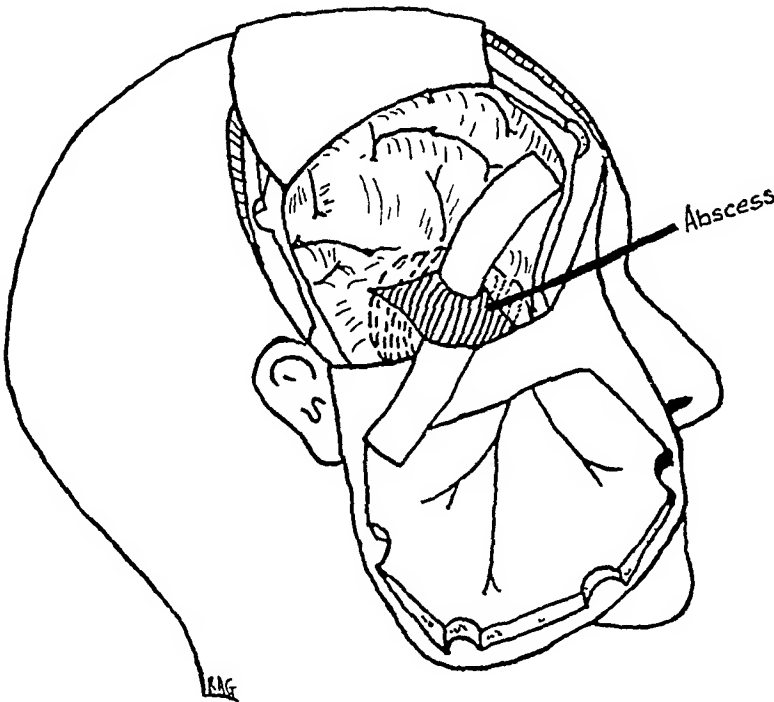


FIG. 1.—Case 1. Schematic diagram showing location of abscess in right temporal lobe.

wall showed it to be composed of a stout fibrous stroma, in which many short glial fibrils were to be seen together with numerous blood vessels, many of which showed proliferative changes. Plasma cells, lymphocytes, and old polymorphonuclear cells were present.

Subsequent Course—The patient made a rapid and uneventful convalescence. The neurologic signs disappeared and she has remained well to date.

COMMENT—The history given by this patient should have suggested the possibility of brain abscess. The relatively long interval between the tonsillectomy and the development of intracranial symptoms seemed to exclude this diagnosis. The bilateral sixth and seventh cranial nerve impairment, without other signs except intracranial hypertension, made ventriculography necessary. The fortunate surgical management of the lesion by intact, complete removal prevented the fatal complication—meningitis. The smooth un-

complicated convalescence and the continuance of the patient's good health up to the present time, two and one-half years, commend this method of treatment.

Case 2—Synopsis Symptoms for 14 weeks Signs suggestive of expanding left cerebral lesion Cannula struck abscess during ventriculography Abscess exposed and removed without rupture Recovery

J F M, Hosp No 35238, male, age 26, was admitted to the University Hospital January 12, 1937, having been referred to Dr F C Grant by Dr Marshall W Dyer, Syracuse, N Y The patient was well until 14 weeks before admission to the hospital, when he began complaining of projectile vomiting This vomiting bore no relationship to meals or time of day and continued up until the time of admission One week after the onset he developed left-sided headache which subsequently became generalized Shortly afterward he had periodic attacks of dimness of vision While walking he noticed he tended to deviate to the right and on numerous occasions became dizzy when bending over

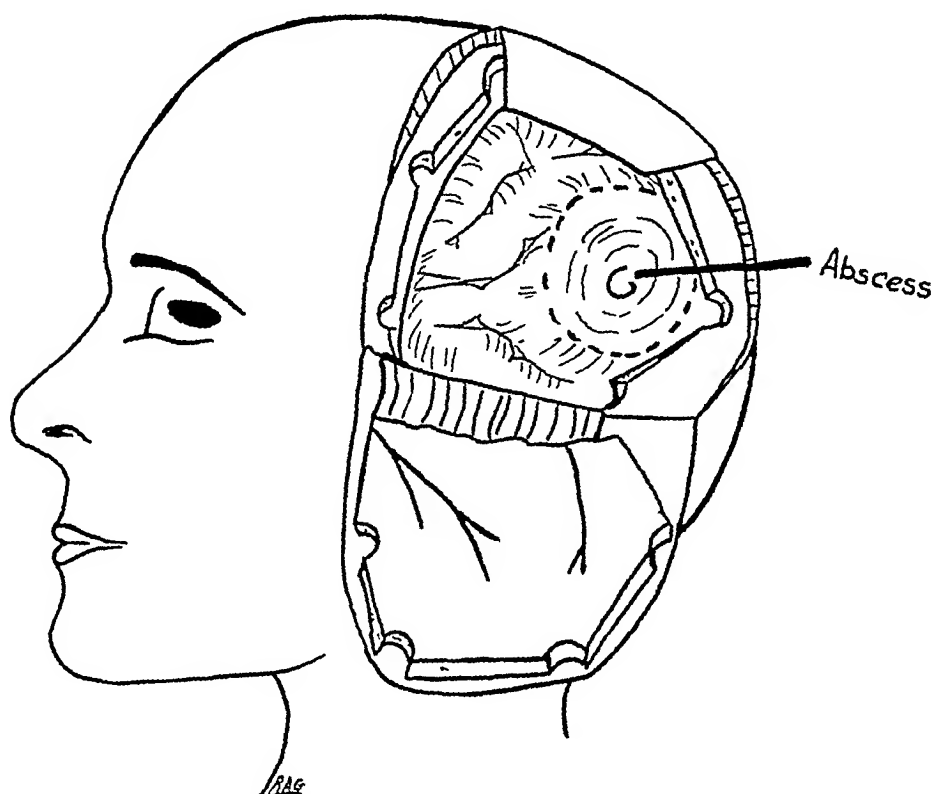


FIG 2—Case 2 Schematic diagram showing location of abscess in left occipital lobe

Physical Examination—The patient was normal except for dental and tonsillar sepsis Neurologic examination revealed a fair mental orientation, dysarthria with test phrases, left sixth nerve palsy, choked disks of four to five diopters, positive tremor sign on the right, abortive ankle clonus on the right together with mild increase in reflexes on the right side of the body, dysnergia in finger to nose test on both sides unsteady gait, and poor associated movements on the right side Temperature pulse and respirations were normal The leukocyte count 10,600, and the Wassermann negative The visual fields showed a marked contraction of both temporal fields, especially on the right, and a complete right homonymous hemianopia Roentgenograms of the skull showed erosion of the posterior clinoids and dorsum of the sella with some forward displacement of the top of the dorsum

Operation—January 22, 1937 Dr F C Grant performed a ventriculogram for the purpose of localization A solid mass was encountered by the cannula when attempting to enter the posterior horn of the left lateral ventricle Predicated upon this, a left

occipitoparietal bone flap was reflected. On the cortex, in the occipital lobe (Fig 2), a grayish-yellow, massive tumor was exposed. This tumor was carefully dissected from its bed without damaging it. After complete hemostasis had been secured, the wound was closed. The tumor measured approximately 6x4x4 cm.

Pathologic Examination—Section of the tumor revealed it to be an abscess containing thick greenish pus. The wall was quite thick and contained a few large blood vessels. Microscopic examination of the wall showed it to be composed of a dense fibrous structure arranged in parallel rows. Among these fibers were numerous fibroblasts and scattered polynuclear cells.

The patient made a rapid and uneventful convalescence. On discharge practically all of the neurologic signs had disappeared but the disks showed a choking of two diopters.

Subsequent Course—The patient has been seen since operation. The vision and visual fields have improved. However, in the six months following removal of the abscess, three generalized major convulsions have occurred. He was given small amounts of phenobarbital and has had no attacks for the past 18 months.

COMMENT—This patient presented essentially the same problem as the case just described. The history was longer and the neurologic signs were suggestive but not conclusive of exact localization. The abscess was exposed by an osteoplastic flap and completely removed without damage. The rapid convalescence and the necessity of only 20 days' hospitalization further emphasize the rationale of this method of treatment.

Case 3—Synopsis Intracranial symptoms for two weeks following mild head injury and streptococcal sore throat. Signs of intracranial hypertension and a right parietal lesion. Craniotomy, tap of abscess by exploring cannula, and complete enucleation. Recovery.

S. K., Hosp. No. 39361, male, age 21, was admitted to the University Hospital, June 6, 1938, having been referred by Dr. C. C. Neff, York, Pa. The patient had been perfectly well until two weeks before admission, when he bumped his head on a beam. He did not become unconscious nor were there any ill effects from this accident. Shortly afterward the patient developed a sore throat which lasted one week. The infection was alleged to be caused by the streptococcus. One week before admission he had an attack in which both arms and legs "stiffened," but no loss of consciousness occurred. This attack began in the left arm and spread to involve the rest of the body. It lasted approximately ten minutes. During the next three days he had three to four similar attacks. Since then the patient has become progressively more dizzy, especially when attempting to walk. At about the same time these attacks began he developed right frontal headaches. For the several days before admission the left arm and hand had become weak.

Physical Examination—The patient was acutely ill. Temperature 99° F, pulse 80, respirations 20. Neurologic examination. The patient was definitely lethargic, the eye-grounds showed a bilateral papilledema of between two to three diopters. The visual fields, to gross tests, were normal. There was a left central facial weakness. The corneal reflex was decreased on the left. The left arm and hand were weak in all movements and a similar but less marked weakness was demonstrated in the left leg. Reflexes in the left arm were increased over those in the right. In the lower extremities, the reflexes were bilaterally exaggerated but equal. A sustained ankle clonus was present on both sides. The left side of the body, including the face, showed a reduction to all forms of sensation, and the left hand showed a loss of stereognostic sense. White blood count 20,300, spinal fluid pressure was 300 mm. of water, and showed four cells per cubic millimeter.

Operation—June 2, 1938. Dr. L. Wemberger performed bilateral frontal and parietal trephines. No hematoma was found. The ventricles were tapped and the left was found to be larger than the right.

On June 3, 1938, Dr. F. C. Grant reflected a right frontoparietal bone flap. The

brain was under marked tension and the dura was opened rapidly. A subcortical lesion was indicated by widening of the gyri in the parietal and temporal lobes. A cannula was introduced in this area and it entered an abscess (Fig 3). Two cubic centimeters of pus were obtained. The cannula was withdrawn. The dura was closed except at the base of the defect over the temporal lobe beneath the temporal muscle. The dura was then re-opened over the abscess and a transcortical incision was made down to the wall. The abscess was enucleated without rupture. The resulting cavity in the brain was packed with gauze soaked in azochloramine and an incision made in the scalp for its removal at a future time. The bone flap and scalp were replaced and the scalp closed by interrupted silk sutures.

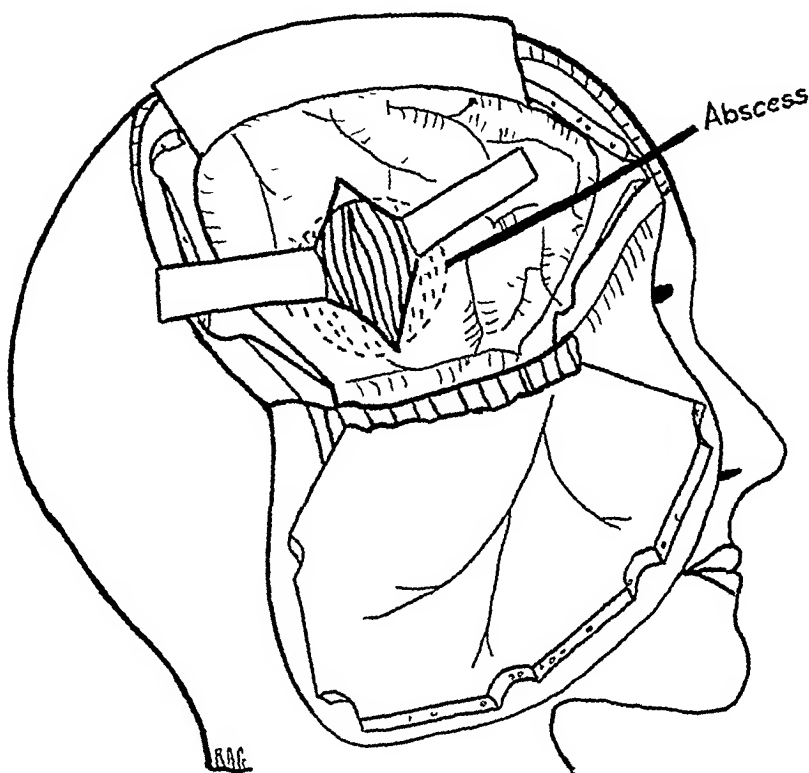


FIG 3—Case 3 Schematic diagram showing location of abscess in right parietotemporal lobes

Pathologic Examination—The abscess (Fig 3) measured $5 \times 4 \times 2\frac{1}{2}$ cm. The wall varied in thickness from 3 to 5 mm. The pus was thick, greenish and foul-smelling. The organism was a gram-negative rod resembling *Haemophilus*. Microscopically, the wall consisted of a dense layer of collagen with few vessels and numerous polymorphonuclear cells.

The packing was removed on the second day but the wound continued to drain for 15 days and then healed. Pressure was controlled by daily lumbar punctures. The weakness on the left side of the body was more pronounced following operation but subsequently improved so that he was able to walk on the ninth postoperative day.

Subsequent Course—Follow-up examinations up to the present time showed that the weakness of the left leg has cleared completely, the arm remains slightly weak and at about monthly intervals the patient has sensory jacksonian attacks in the left arm. Otherwise he feels well.

COMMENT—The particular problem this case presented was to determine the course to be adopted when an abscess is tapped during a craniotomy. In this patient, the cannula was removed and the dura closed in order to maintain

pressure sufficient to keep the subarachnoid space closed. An opening was then made through the dura and brain down to the wall. The abscess was removed through this opening. To prevent possible spread of infection, the cavity was packed with gauze saturated with azochloramine. This course of treatment was effective in preventing meningitis in this patient.

Case 4—Synopsis Symptoms of intracranial involvement for two weeks. Signs of intracranial hypertension. Ventriculogram. Right frontoparietal craniotomy and exposure of abscess. Subsequent removal of wall. Second admission. Removal of infected bone flap. Recovery.

W. T., Hosp. No. 137004, male, age 11, was admitted to the Graduate Hospital, August 25, 1938, having been referred by Dr. Mark D. Grim, Oley, Pa. The patient had been in good health until eight weeks before admission to the hospital, when he developed

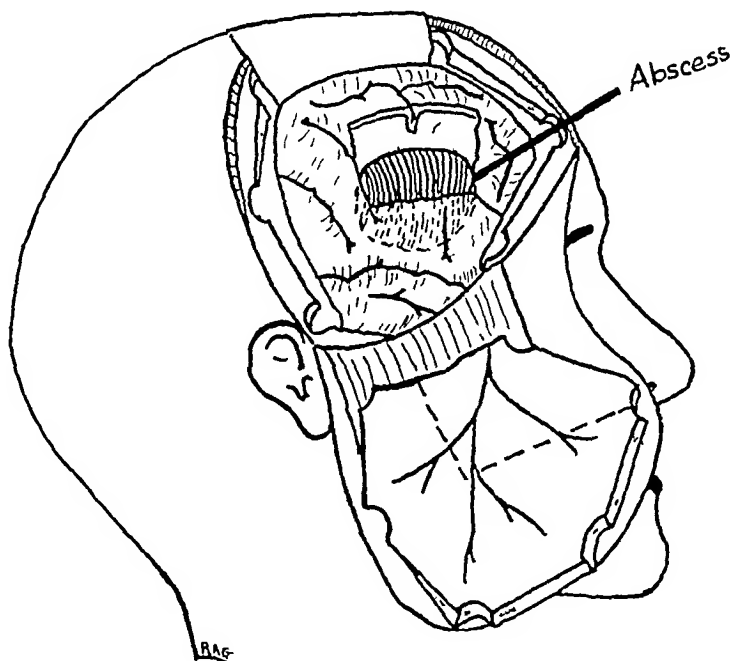


FIG. 4—Case 4. Schematic diagram showing location of abscess deep in right frontal lobe.

frontal headache and a fever of 101° F. These symptoms continued for ten days, when he had a generalized convulsion. Following the convulsion all symptoms subsided. The patient was then well until two weeks before admission, when headache and vomiting began and continued up until admission to the hospital. One week before admission, examination of the eyegrounds showed papilledema of both optic disks.

Physical Examination—This was essentially negative, and the neurologic examination was likewise negative except for a bilateral papilledema of four diopters. Visual fields were full. Barany examination was suggestive of an intracranial lesion. Roentgenograms of the skull and paranasal sinuses were entirely negative. White blood count 10,600, the blood Wassermann was negative.

Operation—August 1, 1938. Dr. R. A. Groff performed a ventriculogram which demonstrated a lesion deep in the right frontal lobe. A right frontoparietal bone flap was reflected and no surface tumor was seen. A mass (Fig. 4) was felt 3.5 cm. below the surface of the frontal lobe in its posterior portion by an exploratory cannula. A block of cortex measuring 5 cm. square was removed over the lesion. A lumbar puncture needle was introduced into the lesion and 1 cc. of thick, yellow pus was obtained. Examination

of this pus showed many gram-positive Cocci. An attempt was made to enucleate the abscess but the wall was too thin. Sutures were then placed in the wall at its thickest portion. The dura and bone were removed over the lesion. Iodoform packing was placed in the cavity over the abscess and brought out through a separate overlying scalp wound. The remaining dura was sutured in position, the bone flap wired to the skull, and the scalp closed in two layers.

Postoperative Course—The night of the operation, the abscess had pushed its way to the scalp edge, displacing the packing. A suction tip was inserted in a seepage point on the wall and two ounces of pus were removed. The opening in the wall was enlarged and packed tightly with iodoform gauze. Six days later, after signs of infection had subsided, the wall was teased out of its bed through the overlying scalp wound. During this maneuver the ventricle ruptured into the wound. This complication was treated by antiseptics to the surrounding scalp and application of sterile dressings. The cerebrospinal fluid leak continued for ten days and then stopped. Several days later pus was evacuated



FIG. 5—Case 2. Postoperative photograph of patient showing well healed scar following a left occipital craniotomy.

from above the right eyebrow and a sponge removed which had been left in at the time of operation. Both wounds healed subsequently and the boy was discharged 38 days after operation.

Subsequent Course—On November 7, 1938, the patient was readmitted because of a draining sinus along the upper medial limb of the scalp incision. Roentgenograms of the skull demonstrated an osteomyelitis of the bone flap. The diseased bone was removed and the patient discharged 58 days later with wound healed except for a small area at the site of the previous drainage tract. Since discharge (Fig. 5) from the hospital following his second admission, the wound has healed and the boy remains well and is attending school.

COMMENT—The surgical problem presented by this patient was similar in many respects to Case 3, except that the wall was too thin to permit enucleation at the time of the original operation. The fact that the abscess migrated to the surface indicated that the abscess would probably have delivered itself if sufficient time had been given. Kahn³ has demonstrated this very dramati-

cally The abscess cavity, however, was evacuated of its contents, packed with iodoform gauze and after evidences of active infection subsided, its wall was removed The cerebrospinal fluid leak which followed was alarming but stopped under conservative treatment The subsequent development of an infection in the bone flap was caused by an overlooked sponge

Case 5—*Synopsis* Severe head injury followed by symptoms and signs of focal brain disease with intracranial hypertension Exploratory trephines and bilateral subtemporal decompression Removal of three abscesses in stages through left subtemporal decompression

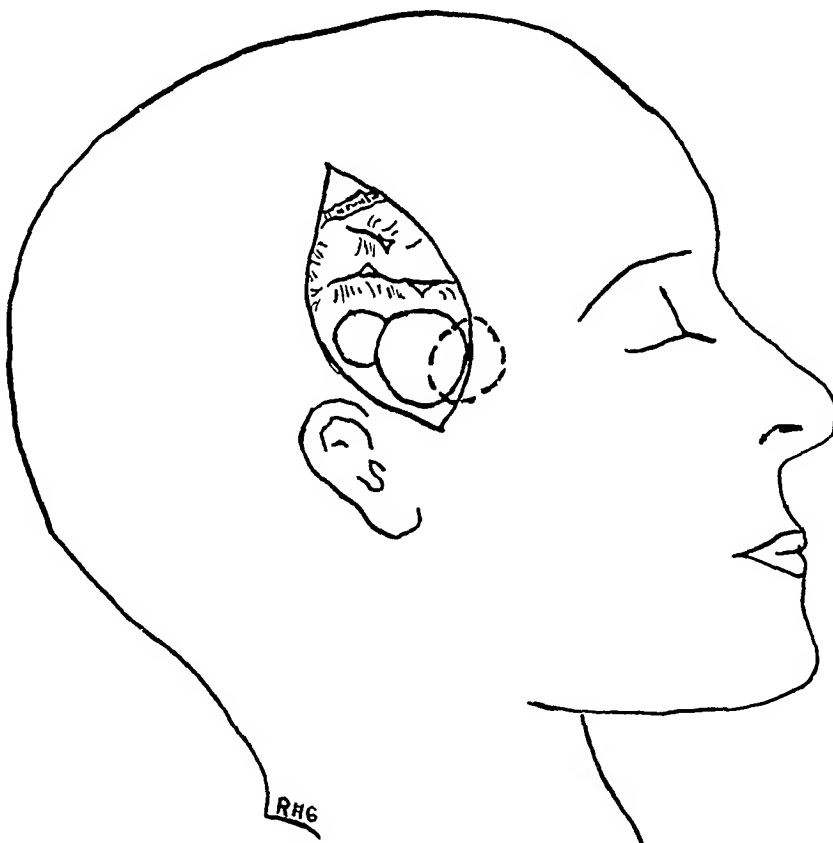


FIG 6—Case 5 Schematic diagram showing approximate location of abscesses

J R C, Hosp No 35637, male, age 7 was admitted to the University Hospital, March 4, 1937, having been referred by Dr B L Hull, Altoona, Pa The patient had been well until nine weeks before admission when he fell from an embankment, striking the left frontal bone He was unconscious at the time of the injury, subsequently regained consciousness and several hours later lapsed into unconsciousness He remained in this state for 18 days During this period a hematoma of the scalp developed over the left temple, which became infected, drained for six days and then healed Five weeks before admission, or four weeks after injury, the patient had several generalized convulsions but improved and was out of bed Up to one week before admission to the hospital, he had no complaints except that he tired easily One week before hospitalization, or eight weeks after injury, the patient developed headache, nausea and vomiting During the next few days these symptoms increased in severity He became irritable, cried easily and developed weakness of the right face and upper extremity

Physical Examination—Temperature 99.3° F, pulse 102, respirations 26 The pa-

tient was drowsy but could be aroused easily. A scar was present over the left temple. Neurologic examination demonstrated weakness of the right lower face, bilateral choking of four diopters, a paralysis of the right upper extremity and a paresis of the left lower extremity. The reflexes on the right side were decreased and a Babinski was present on the right. White blood count 13,500, urine normal, spinal fluid pressure 750 Mm of spinal fluid and the fluid contained six lymphocytes per cubic centimeter.

Operation—March 5, 1937. Dr. F. C. Grant made trephines over the left frontal and parietal bones. No hematoma was found but the brain was under marked increased pressure. A cannula was inserted into the brain through the frontal bur opening and increased resistance was encountered at a depth of 3 cm. A third trephine opening was made in the upper limits of a subtemporal decompression. This opening was enlarged to the size of a decompression and the dura opened. During exploration, the patient strained and an abscess (Fig. 6) ruptured into the wound. About an ounce of pus was recovered. The wall was drained by rubber tissue and the wound left open. The pus contained Type I pneumococci on culture.

Postoperative Course—Antipneumococcic serum was administered to the extent of 50,000 units. A cerebral fungus developed, which was amputated seven days after operation. That portion removed contained part of the abscess wall. During the following 24 hours the fungus increased greatly so that a right subtemporal decompression was performed and the right ventricle tapped. The fungus was explored and the remainder of the original abscess wall removed together with two additional well walled-off abscesses.

The fungus increased in size and drained pus for a number of weeks. Intracranial pressure was reduced by lumbar punctures. These drainages were done as often as every 12 hours during the acute stages. Nine weeks after the last operation, the fungus was clean and had receded sufficiently to allow skin grafting over it. Two weeks later, or three months after admission, the patient was discharged from the hospital.

Pathologic Examination—The abscess wall was composed almost entirely of collagen fibers arranged in parallel rows. Among these fibers were a few glial fibrils and numerous polynuclear leukocytes.

Subsequent Course—One and one-half years later, the patient showed a useful right leg, a less useful right arm and a slight speech defect. These signs were much improved over those recorded when the patient was discharged from the hospital.

COMMENT—The approach to the problem presented by this patient was different from that described in the preceding cases. In exploring for a subdural hematoma, an abscess ruptured into the field of a subtemporal decompression. The only alternative was the institution of drainage. A cerebral fungus quickly developed, was explored, and two well walled-off abscesses found and removed. The cause for the herniation was not only a focal cerebritis but two additional abscesses. Had this herniation not been explored, it is questionable whether this patient would have survived. Therefore, other abscesses as well as a cerebritis may be the cause of cerebral herniation.

Case 6—*Synopsis*. Symptoms and signs of intracranial hypertension for one month. Lesion localized to left side by shift of calcified pineal gland as seen roentgenologically. Abscess in left frontal lobe tapped and drained. Subsequently refilled, attempted removal of wall by craniotomy, rupture of wall, later, removal of two-thirds of wall. Second abscess formed, drained, and complete removal of wall. Third abscess collection developed, wall opened and packed. Recovery.

M. B., Hosp. No. 132888, male, age 17, was admitted to the Graduate Hospital, January 10, 1938, having been referred by Dr. Henry Dintenfuss, Philadelphia, Pa. In August, 1937, this patient had had a right ethmoidectomy. Since that time he complained of generalized weakness. One month before admission to the hospital he developed severe frontal headaches and diplopia on looking to the left. The headaches became progressively

more severe and at the time of his admission, were almost continuous. One week before admission he had an attack of nausea and vomiting, associated with vertigo. From this time on he became increasingly more drowsy.

Physical Examination—This was essentially negative. Temperature 99.6° F, pulse 60, respirations 24. Neurologic examination disclosed a patient mentally quite drowsy, showed a slight right lower facial weakness, a paralysis of the right external rectus, an increase in the reflexes on the left side, and the eyegrounds showed a papilledema of four diopters in both eyes. Roentgenologic examination of the skull demonstrated a calcified pineal gland, which was shifted from the left to the right side of the skull. The examination of the sinuses showed a densely clouded left antrum. *Preoperative Diagnosis*—Left frontal lobe brain abscess.

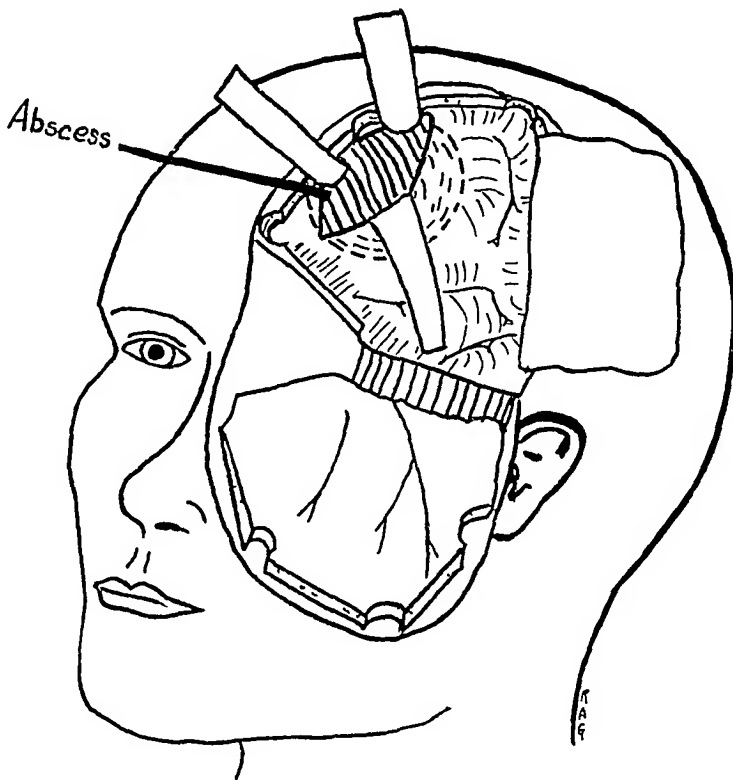


FIG 7—Case 6. Schematic diagram showing location of first abscess. The four other abscesses present in this patient were lateral and anterior to this abscess.

Operation—January 12, 1938. Dr. R. A. Groff placed a trephine over the left frontal lobe and an abscess was palpated (Fig. 7) 2 cm. beneath the cortex. The wound was packed with iodoform gauze, and 24 hours later, the abscess was opened and a drainage tube inserted.

Postoperative Course—The abscess continued to drain, and on the eleventh day following the institution of drainage, the eyegrounds showed a sudden increase in papilledema with fresh hemorrhages. A right subtemporal decompression was performed and the left frontal lobe explored through a clean trephine opening but no further pus was obtained. Eight days later, the tube was changed in the abscess and approximately 25 cc. of pus were obtained. Subsequently drainage ceased, the tube was removed, and the patient discharged 45 days after the initial drainage of the abscess.

Readmission—April 15, 1938. Following discharge from the hospital, the patient remained in good condition up until the day before his present admission to the hospital, at which time he developed a continuous headache, became nauseated, and vomited several

times. Neurologic examination showed a right lower facial weakness and a definite increase in tension of the right subtemporal decompression.

Operation—April 28, 1938. Dr. R. A. Groff performed a left frontoparietal craniotomy, under avertin anesthesia. The dura was opened and the abscess outlined by means of an exploratory cannula. An incision through the cortex, down to the wall, was made and an attempt undertaken to enucleate the abscess. The wall, however, was very firmly adherent to the falx. In attempting to break up these adhesions, the abscess ruptured. The hole in the abscess was then plugged, the bone flap removed in order to prevent it from becoming infected, and the scalp closed with silkworm sutures. An incision was made through the scalp in order to permit access to the abscess. This open wound was packed with iodoform gauze.

Subsequent Course—Following this operation, no evidence of meningitis appeared. On the following day, the packing was removed and the abscess wall opened. Approximately 70 cc of pus were removed. The abscess wall was then packed with iodoform gauze. Following this, drainage continued for several weeks, subsided, and the patient was discharged from the hospital 70 days following the institution of drainage.

Readmission—September 5, 1938. The patient had developed symptoms and signs of a refilling of the abscess.

Operation—September 6, 1938. Dr. R. A. Groff exposed the abscess by opening the scar which had been made previously. Sutures were placed in the wall. The wall was opened and two ounces of pus obtained. The wall was then packed with iodoform gauze. Four days after opening the abscess, the wall was dissected out. Unfortunately, only two-thirds of the wall was obtained. The remaining portion was firmly adherent to the falx. In removing the wall, the ventricle ruptured into the wound. This was treated by light packing. Twenty-six days later the wound was completely healed and the patient was discharged.

Readmission—November 26, 1938. The day before admission the patient had a generalized convulsion. At the time of his admission, the examination was essentially negative except for a small drainage tract at the site where the abscess had been drained. Roentgenograms of the skull demonstrated what was thought to be a beginning osteomyelitis of the bone edge in this vicinity.

Operation—December 3, 1938. Dr. R. A. Groff investigated the sinus tract, and the presumably infected bone was rongeuured away. No evidence of osteomyelitis could be seen. The wound was closed with drainage. The drain was removed on the third day and the discharge ceased on the twelfth day. The patient was discharged 14 days following operation.

Readmission—February 6, 1939. Two weeks before this admission, the patient contracted a cold and was sent to bed by the family physician who diagnosed the illness as "grippe." During succeeding days, decompressed areas became tense and began to bulge. After a period of ten days in bed, patient was pronounced cured of "grippe" and came to hospital because the decompression areas were "hard and tender."

Operation—February 11, 1939. Dr. R. A. Groff performed a ventriculogram which demonstrated a lesion in the left frontal lobe. The scar, through which two previous abscesses had been drained and enucleated, was opened and the abscess wall exposed. The abscess was opened widely, evacuated and packed with iodoform gauze.

The cavity of the abscess stopped discharging two weeks later and began filling-in with fresh granulation tissue.

Three weeks after admission, the ventriculogram was repeated and the defect previously seen was still present but less marked. The patient was discharged six weeks after admission, wound not completely healed.

Readmission—April 4, 1939. Four days before admission, the patient developed a "head cold" and subsequent to this, the decompressed areas became extremely tense. Headaches, nausea and vomiting brought him back to the hospital.

Operation—April 20, 1939. The previous scar was opened by Dr. R. A. Groff. Two

abscess cavities were evacuated of one and one-half ounces of pus. These cavities were opened widely and packed with gauze.

Convalescence was interrupted by a generalized convulsion, nine days after operation. Three days later, packing was removed from cavities, since they were granulating-in rapidly. The decompressed areas became concave for the first time since treatment was started. The wound was practically healed when patient was discharged, May 6, 1939.

Since discharge from the hospital, the patient has remained symptom-free, the wound is well healed and decompressed areas are soft and sunken.

COMMENT—The neurologic findings in this patient were indefinite but seemed to suggest a right frontal lobe lesion. Roentgenograms of the skull disclosed a calcified pineal gland displaced to the right. This evidence definitely placed the lesion on the left side and showed the value of roentgenograms of the skull and the presence of a calcified pineal gland.

The surgical treatment in this patient embodied three methods: Tap and drainage, enucleation, and marsupialization. Rubber drainage proved ineffectual. Enucleation was unsuccessful in the first abscess because the wall was firmly adherent to the falx. Only two-thirds of the wall of this abscess was removed. A second abscess was enucleated in stages. Marsupialization was employed twice for two additional abscesses. This method, described by HOMAN,⁴ has for its principle uncapping the abscess, fixing the wall to the scalp, and packing.

Case 7*—Synopsis *History of two head injuries followed by signs of increased intracranial pressure. Two tapplings of right frontal lobe abscess. Craniotomy and removal of four encapsulated abscesses. Meningitis. Death.*

W. P., Hosp. No. 36666, male, age 20, was admitted to the Philadelphia General Hospital, April 26, 1937, having been referred by Dr. J. J. Curtin, Philadelphia, Pa. At age 15, the patient had a head injury with loss of consciousness, requiring hospitalization for 30 days. Several weeks following this injury, he became blind in the right eye, was hospitalized and subjected to an encephalogram. The vision in the right eye returned and the patient remained well until November 20, 1936. On this day, the patient struck his head against an iron pipe, became very dizzy, but did not lose consciousness. Two weeks later he developed headache. On December 22, 1936, he had an attack of unconsciousness during which he bit his tongue. This attack lasted 15 minutes and was not associated with convulsive movements. On January 4, 1937, a similar attack occurred and the patient was studied in another hospital for four weeks. He was discharged feeling well. On April 24, 1937, his headaches returned, and he was unable to hold anything on his stomach. His vision became "blurry." He was admitted to this hospital two days later with an increase in symptoms.

Physical Examination—Temperature 99° F, pulse 50. Neurologic examination demonstrated definite clouding of consciousness, tenderness over the right temporal area, and slight blurring of the optic disks. The spinal fluid pressure was 21 mm Hg, and the fluid contained 281 cells, 24 per cent of polymorphonuclears and 76 per cent lymphocytes. Roentgenographic studies of the skull and sinuses were essentially negative except for "sclerosis" of the right sphenoid ridge.

Operation—April 30, 1937. Dr. R. A. Groff made a trephine opening over the right frontal lobe just above the fascial attachment of the temporal muscle. An exploratory cannula encountered increased resistance at a depth of 3 cm, anterior and medial to the trephine opening. This mass was penetrated, and 30 cc of greenish-yellow pus were

* Previously reported as Case 4, Brain Abscess of Undetermined Etiology, J. C. Yaskin, F. C. Grant and R. A. Groff, *ANNALS OF SURGERY*, 107, 492, April, 1938.

evacuated. The cavity was washed out with normal saline and the cannula left *in situ*. Forty-eight hours later, the cannula was removed because no drainage had occurred and normal saline washings of the cavity did not recover pus. The pus contained Type IV pneumococcus.

Postoperative Course—The patient recovered rapidly and was discharged. Three weeks later he returned to the hospital with signs of refilling of the abscess. In attempting



FIG 8—Case 7. Photograph of the brain showing the area in right lobe from which four abscesses were removed. Note the absence of infection over this area. The infection which terminated patient's life is shown confined to the base of the brain.

to evacuate the abscess for the second time, the cannula would not penetrate the abscess wall because of its thickness. A lumbar puncture was performed. Following this relief of pressure, the symptoms and signs subsided. Operation for removal of the wall was contemplated but the patient refused and left the hospital.

On July 5, 1937, he was admitted to the University Hospital, with symptoms and signs of refilling of the abscess in the right frontal lobe.

Operation—July 6, 1937. Dr. F. C. Grant exposed the right frontal lobe. The abscess was identified, and just as its enucleation had virtually been completed, the wall ruptured. A second abscess was palpated in the temporofrontal lobes and, similarly, as

it was being enucleated, its wall ruptured. Two other abscesses were removed. During the operation a fracture in the posterior wall of the frontal sinus was exposed. The wound was cleansed, the dura closed and the flap and scalp replaced with drainage.

Postoperative Course—Three days later, clinical evidence of meningitis developed, which was confirmed by purulent drainage from the wound and infected spinal fluid. The patient died 16 days after operation.

Autopsy—The brain (Fig. 8) showed evidence of a marked basilar meningitis. The right frontal lobe, from which four abscesses had been removed, showed marked necrosis and destruction, with little evidence of infection. On section of the brain, there was a marked ventriculitis. Microscopic studies of the brain showed a diffuse purulent meningo-encephalitis.

In addition, a fracture was demonstrated extending from the frontal to the ethmoid sinuses. The adjacent bone was infected and these sinuses contained pus. The conclusion from these findings was that the ethmoid and frontal sinuses were the primary focus of infection.

COMMENT—The method of treatment employed in this patient seems to us to be ideal. First, initial tapping of the abscess in order to localize and estimate the thickness of the wall. Second, direct exposure and enucleation of the abscess. The unfortunate circumstance in this patient was the presence of more than one abscess, as well as the osteomyelitic area about the frontal and ethmoidal sinuses which would have, in all probability, continued to reinfect the brain.

ANALYSIS—Source of Infection The source of the infection from which the abscess in the brain developed was unknown in three patients, although in one of these, infected tonsils may have been the contributing factor. The remaining four patients developed a brain abscess during a chronic infection of the frontal and/or ethmoid sinuses. In these latter patients, roentgenographic studies demonstrated the sinus disease, but in no instance was there evidence of osteomyelitis of the bone in or about the sinuses.

Description of Abscess—The locations of the abscesses were. Three in the frontal lobe, two in the temporal lobe, and one each in the occipital and parietal lobes. The depth of the abscesses in relationship to the surface of the brain varied. One lesion presented itself on the surface of the brain and, upon first inspection, was thought to be a meningioma. The remaining lesions were located beneath the surface, varying from a depth of 1 to an extreme distance of 4 cm.

Four patients had single abscesses, whereas the remaining three had multiple abscesses. Where multiple abscesses were present, they were in close relationship to each other and confined to one lobe.

Only one abscess had a stalk. This stalk extended from an infected fracture line involving the frontal and ethmoid sinuses, through the dura to the region of the abscesses in the frontal lobe. Four abscesses were present in this patient.

All abscesses had walls which were sufficiently firm to permit enucleation.

Diagnosis and Treatment—The preoperative diagnosis in these seven patients influenced the method of treatment. In four cases (Cases 1, 2, 3 and

4), the primary diagnosis was brain tumor and in two of these cases (Cases 1 and 2), brain abscess was not considered a possibility. All four patients were subjected to a ventriculogram, when localization could not be made clinically, and then to a craniotomy. When the diagnosis of brain abscess had not been considered, the lesion was enucleated. That the lesion was an abscess was not appreciated until it was sectioned in the laboratory. When the diagnosis of abscess had been made preoperatively, a needle was introduced into the lesion after exposure had been made. Enucleation was performed immediately after the tapping in the one patient, whereas, in the second patient, the abscess was removed several days following the craniotomy.

A fifth patient (Case 5) was diagnosed a chronic subdural hematoma. After exploratory trephines had been made, a subtemporal decompression was carried out. An abscess ruptured into the operative field during this procedure. Subsequently the wall of the ruptured abscess, together with two additional intact abscesses, was removed.

The diagnosis of the remaining two patients (Cases 6 and 7) was made preoperatively. After preliminary tapping and rubber tube drainage had been performed unsuccessfully, both were subjected to a craniotomy. The wall of the abscess was so firmly adherent to the falx in one patient (Case 6) that it ruptured while attempting to remove it. Part of the wall was removed a few days later. Several months afterward, a second abscess became apparent, this was drained and the wall removed completely. Approximately six months later, two abscesses were localized and treated by marsupialization.

The last patient (Case 7) had four abscesses, two of which ruptured during removal. One of these abscesses had a stalk which connected with an infected fracture line in the frontal and ethmoid sinuses. This stalk was disturbed during the operation and meningitis terminated the patient's life. This is the only death in this series.

Complications—The only complication in the four patients with a single abscess was an osteomyelitis of the bone flap. This unfortunate circumstance could have been avoided, since it was the direct result of the operator's (R. A. G.) overlooking a sponge. The complication which arose in the treatment of the patients with multiple abscesses was meningitis in one patient. This was the result of a disturbance of the stalk of one of the abscesses and, in addition, the rupture of two abscesses during removal. In another patient, a cerebral herniation resulted, and within this mass two walled-off abscesses were found and removed.

COMMENT—The smooth, rapid and uncomplicated convalescence in the four patients with single abscesses, if one overlooks the avoidable complication of osteomyelitis of the bone flap in the one patient, commends this procedure as the most satisfactory treatment for brain abscesses which have a firm wall. The complications of cerebral herniation, cerebral fungus, and an alarming increase in intracranial pressure are avoided. The constant wound care necessitated, when drainage methods are employed, is eliminated. The postoperative care is reduced to the management of a patient who has been operated

upon for a brain tumor, and the morbidity rate in these patients, at the present writing, is extremely low. These facts justify the surgical procedure of enucleation of a well walled-off brain abscess.

The term "capsule" has been purposely discarded, because the meaning conveyed by it is a covering for organs, or certain tumors. The layer of tissue about an abscess is a barrier to enclose or confine the infection. This barrier or wall is not a capsule nor is it referred to as such in abscesses in other parts of the body. We are in accord with Atkinson,⁷ that the tissue surrounding an abscess should be called the "wall."

The enucleation of a brain abscess by direct exposure depends upon the firmness of the abscess wall. Therefore, this fact must be known before enucleation is contemplated. The most practical way in which this information can be determined is by exploration with a cannula through a trephine opening. If the cannula imparts the information that the wall is firm, enucleation of the abscess by direct exposure can be carried out immediately. On the other hand, if the cannula passes through the wall without much resistance, it will be necessary to adopt measures to allow more time, in order that the wall of the abscess may become firmer and thicker. These measures may be one of several, repeated tapplings of the abscess, such as was done in Case 7, or repeated tapplings and a subtemporal decompression, in order to control increase in intracranial pressure and save vision, as was carried out in Case 6. A craniotomy may be performed without opening the dura, as suggested by Vincent. The latter method was utilized in a modified form in Case 4. In this patient, after the abscess had been exposed, it was found that the wall was not thick enough to permit enucleation. The abscess was removed several days later.

Tapping the abscess gives the additional information of the type of organism which is responsible for the infection. If this organism is one of those susceptible to the several chemotherapeutic agents, they can and should be given, as suggested by Rowe⁶ and Bucy.⁷

Multiple abscesses of the brain present a different problem. The three cases presented here were more or less ideal in that the abscesses were grouped together. Two of these patients were treated successfully, the third died of meningitis. The difficulty with this problem is that the walls of the several abscesses are not in the same stage of development. Thus, if a preliminary tap is made and the cannula strikes an abscess with a firm wall, and direct exposure discloses several lesions, one or more of them may not have a wall which is firm and sufficiently thick to remove without rupture.

Abscesses resulting from penetrating wounds and direct extension of the infection from either an infected mastoid or frontal sinus cannot be treated by this method. The one patient in this series (Case 7), whose lesion had a stalk leading from an infected frontal and ethmoid sinus, died from meningitis as a result of disturbance of this tract. The methods of King,⁸ Horrax⁴ and Kahn³ are more applicable for treating this type of pathology.

SUMMARY

The records of seven patients with brain abscess, in whom the surgical treatment was enucleation by direct exposure, have been presented

The reasons for considering the method of enucleation of firmly walled-off brain abscesses as the most satisfactory form of treatment have been given

The problems which arise in connection with this method of treatment have been discussed, and an outline has been given for the management of patients in whom the diagnosis of brain abscess has been made

REFERENCES

- ¹ Sargent, P Remarks on Drainage of Brain Abscess Brit Med Jour, 2, 971-972, December 1, 1928
- ² Vincent, C Sur une methode de traitement des abces subaigus des hemispheres cerebraux, large decompression, puis ablation en masse sans drainage Gaz Med de France, 43, 93-96, February 1, 1936
- Idem* Nueva tecnica para el tratamiento de los abscess sub-agudos de los hemisferios cerebrales, su ablacion en masa, previa decompression Rev olo-neuro-oftal, 11, 159-164, June, 1936
- Idem*, with David, M, and Askenasy, H Sur une methode de traitement des abces subaigus et chroniques des hemispheres cerebraux, large decompression, puis ablation en masse sans drainage, ou ablation en masse sans drainage Jour de chir, 49, 1-46, January, 1937
- ³ Kahn, E A Treatment of Encapsulated Brain Abscess J A M A, 108, No 2, 87, 1937
- ⁴ Horrax, G A Method for the Treatment of Certain Chronic Encapsulated Brain Abscesses Surg Clin North Amer, 14, 1179-1186, 1934
- Idem* Brain Abscess Brit Jour Surg, 25, 538-552, 1938
- ⁵ Atkinson, E M Abscess of the Brain Its Pathology, Diagnosis and Treatment Hunterian Lecture Lancet, 1, 483-488, March 10, 1928
- ⁶ Rowe, S N The Use of Sulfanilamide in the Treatment of Brain Abscess ANNALS OF SURGERY, 107, 620-626, April, 1938
- ⁷ Bucy, P C Sulfanilamide in the Treatment of Brain Abscess and Prevention of Meningitis J A M A, 111, 1639-1641, October 29, 1938
- ⁸ King, J E J The Treatment of Brain Abscess by Unroofing and Temporary Herniation of Abscess Cavity with the Avoidance of Usual Drainage Methods Surg, Gynec and Obstet, 39, 554-568, November, 1924

THE TREATMENT OF ADDISON'S DISEASE BY THE IMPLANTATION OF SYNTHETIC HORMONE*

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It is highly probable that human beings have died from destruction of their adrenal glands since the beginning of the race, but the clinical picture incident to this destruction has been recognized for only 84 years, and the physiologic alterations that are induced by adrenal disease have been understood for less than 10 years. Finally, a crystalline substance which rectifies these alterations, which abolishes the symptoms, and prevents death, has been available for less than two years. It is the purpose of this communication to tell of 17 patients who have been given this specific substance in the form of pellets implanted subcutaneously.

Since 1855, it has been known that destructive lesions of the adrenal glands cause weakness, loss of weight, hypotension, digestive disturbances, pigmentation and death. An excerpt from Addison's¹ original paper will suffice to show how clearly he grasped the essential features of the syndrome resulting from adrenal insufficiency.

"The patient, in most of the cases I have seen, has been observed gradually to fall off in general health, he becomes languid and weak, indisposed to either bodily or mental exertion, the appetite is impaired or entirely lost, the whites of the eyes become pearly, the pulse small and feeble, or perhaps somewhat large, but excessively soft and compressible, the body wastes without, however, presenting the dry and shriveled skin and extreme emaciation usually attendant on protracted malignant disease, slight pain or uneasiness is from time to time referred to the region of the stomach, and there is occasional actual vomiting, which in one instance was both urgent and distressing, and it is by no means uncommon for the patient to manifest indications of disturbed cerebral circulation."

"We discover a most remarkable and, so far as I know, characteristic discoloration taking place in the skin—sufficiently marked, indeed, as, generally, to have attracted the attention of the patient himself, or of the patient's friends."

"The disease develops in the third or fourth decade of life, usually quite insidiously, with adynamia and apathy. To these are added disturbances of the digestive tract (constipation, often alternating with diarrhea), and pigmentation of the skin and mucous membranes. The patients succumb under a gradually increasing cachexia, not rarely with stormy terminal manifestations, autopsy almost always shows disease of both suprarenals, mostly tuberculous caseation."

Addison not only gave to the world a concise description of the disease

* Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

which bears his name, but he stated, quite correctly, that any chronic lesion destroying the adrenals would give rise to this syndrome.

In 1875, Greenhow² drew attention to an additional characteristic of the symptomatology of Addison's disease. His outstanding paragraph states: "The asthenia, the constitutional symptoms generally, and the change of colour in the skin are all, it is true, progressive, but not steadily so. The course of the disease, on the whole, is slow and chronic, but it is subject to alternate exacerbations and remissions, usually in some degree dependent upon favourable and unfavourable circumstances but sometimes also, apparently, quite independent of them. During the remissions, strength is in a great degree recovered, appetite improved, sickness abated, the discolouration becomes paler, and, above all, the patient's whole aspect bespeaks that a heavy weight has been lifted from his head. After each fresh exacerbation, however, the patient remains upon a somewhat lower level than during the previous remission. The recovery of strength and the abatement of other symptoms is less marked, and the skin, though paler than during the last exacerbation, is yet visibly darker than before it. Similar alternations may occur several times before the onset of the fatal paroxysm, but on each occasion the patient takes at least one downward step that he never regains."

There were no other noteworthy milestones in the understanding of this disease until 1894, when Oliver and Schaefer³ obtained a strong pressor substance from extracts of the adrenal medulla. This discovery initiated a period of intensive experimental activity, culminating in the isolation of epinephrine in 1904. It was soon realized, however, that the symptoms of Addison's disease were not ameliorated by the administration of epinephrine. Later, it was discovered that the removal of one adrenal, accompanied by the destruction of the medulla of the remaining gland, did not evoke evidence of adrenal insufficiency. From this experiment it was clear that the adrenal cortex is the part of the gland essential for life; thereafter, sporadic efforts were made to extract from the adrenal cortex a substance or substances which would sustain life in adrenalectomized animals. In 1929, a tremendous impetus was given to this search by the announcement of Pfiffner and Swingle⁴ that they had succeeded in preparing a potent cortical extract. Immediately, work was begun in several large medical centers, and scientific publications soon reflected a revival of interest in the adrenal cortex. During the next two years three sets of workers claimed that they had extracts capable of counteracting the effects of adrenal insufficiency in animals. These various cortical extracts, however, gave most disappointing results when given to patients suffering from Addison's disease. The preparation of these extracts was expensive, and the standardization was time-consuming, since each lot had to be separately assayed, but, above all, the effects on the patients were variable and unpredictable. Snell,⁵ at the Mayo Clinic, in 1933, concluded that the life expectancy of patients treated with the several cortical extracts then in use had been only slightly prolonged. Occasionally, patients seemed to show surprising and sustained improvement, but one questions the ad-

visability of attributing these results to the use of an extract, for had these extracts contained a potent cortical substance, then all patients with adrenal insufficiency should have benefited from them. To one who was actively participating in this field of investigation, it seemed that the clinicians suddenly began to recognize many more instances of the disease than ever before. Undoubtedly, some of the therapeutic results accredited to the various cortical extracts, between 1931 and 1933, were obtained from patients suffering from asthenia of nonorganic origin.

The renewed interest in the experimental and clinical evidences of adrenal insufficiency produced two discoveries of fundamental importance. The first of these came in 1933, when Loeb⁶ pointed out the beneficial effect of sodium chloride in the treatment of adrenal insufficiency. The studies of Loeb and his co-workers made it clear that an animal with serious impairment of cortical function loses an abnormal amount of sodium and chloride ions in the urine. Such an animal has a concomitant increased urinary output. These alterations are reflected in the condition of the animal's blood, which shows low values for sodium and chloride and coincident hemoconcentration. Loeb showed that the ingestion of relatively large amounts of sodium salts was beneficial to patients with Addison's disease. Subsequently Truszkowski and Zwemer⁷ demonstrated the advantages of a diet having a low potassium component.

The second fundamental discovery in this field of research came four years later, when Steiger and Reichstein⁸ announced the synthesis of a steroid compound capable of preventing death from adrenal insufficiency. This crystalline compound was desoxy-corticosterone acetate. One year later, Reichstein and von Euw⁹ isolated this same substance from beef adrenal glands, thus proving its natural occurrence. This is the first instance in history in which a hormone has been synthesized before it had been isolated from its natural source.

Dr. George W. Thorn,¹⁰ of the Department of Medicine of the Johns Hopkins Hospital, was fortunate enough to be given some of Reichstein's crystalline substance. At first this was tested on dogs which the author had bilaterally adrenalectomized under spinal anesthesia. It was found that a single daily injection of 1 to 1½ mg. of desoxy-corticosterone acetate maintained a 10 Kg. adrenalectomized dog in good health, even though the animal was being kept on a diet low in sodium chloride and relatively high in potassium. When the injections were stopped, the animal showed a prompt diuresis associated with increased excretion of sodium and chloride and a decreased excretion of potassium, moderate hemoconcentration, and, in addition, it developed weakness, digestive disturbances, and loss of weight. When the administration of the crystalline substance was resumed, these changes were reversed and the animal soon returned to a normal condition. Subsequently, pellets composed of crystals of desoxy-corticosterone acetate were placed subcutaneously in bilaterally adrenalectomized dogs. It was found that this form of therapy maintained the animals in excellent health, if the daily hormone requirement of each dog had been previously determined and sufficient pellets

were implanted to meet these requirements. Removal of the pellets invariably brought on typical metabolic alterations and signs of adrenaal insufficiency. By weighing the pellets before implantation and upon removal, the amount of hormone absorbed was ascertained. The rate of absorption was found to be from 0.25 to 0.40 mg. per day. This relatively slow absorption rate is due to the hardness of the pellets and to the slight water solubility of the compound. It did not vary in different animals. The comparison of the utilization of the cortical hormone when given by daily injections in oil, or when supplied by pellets, showed that the latter form of administration was about 25 per cent more efficient than the former.

The success of pellet therapy in experimental animals prepared the way for the use of the method in patients with Addison's disease. Since September, 1938, Dr. George Thorn and I have treated 17 patients by the implantation of pellets of desoxy-corticosterone acetate. All these patients have been studied on the Metabolic Ward of the Johns Hopkins Hospital. In every instance, the daily requirements of the hormone in sesame oil have been determined before the pellets were inserted. It has been found that 0.5 mg. of the hormone in oil, given by daily injections, requires a tablet weighing 125 mg. It is important to have the patient on standard conditions and to compute each patient's requirement before implanting the pellets. Our usual plan of procedure is to study the patient under basal conditions, and then, after this, to add 10 Gm. of sodium chloride to the patient's diet. We do not modify the potassium content of the diet. On this regimen we give a single daily injection of "Pericorten" (Ciba) varying from 2 to 10 mg., depending upon the patient's needs.

As evidence of adequate treatment we require the patient to maintain (a) Optimum body weight, (b) normal blood pressure with normal plasma volume, (c) positive sodium and chloride balance, and (d) normal concentration of plasma electrolytes. When the hormone requirements of a patient are accurately established, we discontinue the injections in oil and insert subcutaneously a sufficient number of pellets to supply a patient's needs.

The desoxy-corticosterone acetate is sterilized by dissolving it in hot acetone, and subsequently passing it through a Seitz filter. The crystals are treated in an autoclave for a few minutes at low pressure, and for additional protection they are placed in ether just prior to insertion. We are still working on the sterilization of this product and do not think that the most efficient means has as yet been determined.

All operations have been performed under procaine anesthesia. The pellets have been placed in the infrascapular region. Owing to the susceptibility of Addisonian patients to infection, we have insisted on following the most rigid aseptic technic. The operations are performed in the general operating room. In three patients it has been necessary to insert tablets in two sites, and for these we have used a separate table of sterile equipment for the second operation. In one patient we inserted as many as 12 pellets through a single incision.

Operative Technic—The incisions are carried well into the subcutaneous fat, and by inserting and spreading blunt scissors a number of pockets are made in this layer. These pockets radiate from the incision like spokes in a wheel, and are approximately 5 cm long and 1 cm wide. When hemostasis has been completed, a nasal dilator is introduced into each pocket and opened so as to facilitate the insertion of a pellet. By tying a black silk suture with an attached silver clip, a particular pellet may be marked for future identification and removal.

In the 17 patients thus treated from September, 1938 to October, 1939, we have made over 30 implantations. In no instance has there been any evidence of infection. All the wounds have healed *per primam*, and not a single pellet has been extruded from the wound.*

None of the patients has complained of pain or soreness after the introduction of the hormone. By removing and weighing some of the pellets we have established an absorption rate of this compound in human beings. It has been remarkably constant in all the patients and amounts to 0.3 mg per day for each pellet weighing between 100 to 125 mg. This rate is somewhat dependent upon the softness of the pellet and upon the surface area. It is not dependent upon the physiologic needs of the patient, for we have found that patients with severe adrenal insufficiency do not absorb desoxy-corticosterone acetate faster than those who have only a slight insufficiency. Our experience has shown that the pellets placed in the 17 patients, referred to above, have met the patient's requirements for cortical hormone for periods ranging from four to nine months. Several of the patients have had their second implantation, and in one of these there is reason to believe that there has been partial regeneration of cortical tissue.

The results obtained in the 17 patients under observation may be summarized as follows. All but two of the group have returned to full activity, and are working as strenuously as they did before their illness began. One patient nursed her husband through a severe infection, in addition to carrying on with her household duties. Another patient was able to have a tuberculous kidney removed with the help of a few injections of the hormone in oil through the postoperative period. Every patient has gained weight, as is shown in Table I. The average gain for the group has been 5.4 Kg. The improvement in both diastolic and systolic blood pressure has been uniform (Table II).

In none of the 17 has there been any suggestion of hypertension, which we attributed to the careful computation of hormone requirements before the implantation was performed. All the patients had maintained a positive sodium and chloride balance. They have kept normal concentrations of potassium, sodium and chloride ions in the blood plasma. Similarly, the hematocrit and plasma volume determinations returned to normal after treatment was begun and have remained so. Some of the patients have shown a decrease in the pigmentation of their skin, but none of them has lost all the pigmentation. As

* One clinician, who has implanted pellets of testosterone by the punch technic, has reported that a fair number of the pellets are subsequently eliminated through the wound.

far as we can tell, no patient in the group has shown any untoward effect from this form of treatment *

TABLE I
THE EFFECT OF SYNTHETIC ADRENAL CORTICAL HORMONE
ON BODY WEIGHT

Patient	Before Treatment	Present Weight	Duration of Treatment
M M	51 3 Kg	54 0 Kg	380 days
P W	51 0 Kg	55 4 Kg	379 days
E V	54 4 Kg	64 0 Kg	377 days
C N	55 9 Kg	64 3 Kg	372 days
F M	61 2 Kg	65 4 Kg	370 days
J Z	39 3 Kg	44 5 Kg	363 days
A S	57 4 Kg	59 2 Kg	328 days
J S	55 2 Kg	70 1 Kg	290 days
J H	63 2 Kg	69 7 Kg	271 days
D B	64 7 Kg	72 6 Kg	261 days
I B	48 0 Kg	52 1 Kg	234 days
S W	58 5 Kg	64 5 Kg	207 days
R W	71 2 Kg	73 3 Kg	181 days
Y E	51 9 Kg	52 1 Kg	157 days
W B	41 2 Kg	41 6 Kg	150 days
R M	49 6 Kg	54 3 Kg	123 days
F H	59 5 Kg	68 6 Kg	65 days

TABLE II
THE EFFECT OF SYNTHETIC ADRENAL CORTICAL HORMONE
ON BLOOD PRESSURE

Patient	Before Treatment	Present Blood Pressure	Duration of Treatment
M M	83/72	118/94	380 days
P W	96/74	130/80	379 days
E V	94/66	142/98	377 days
C N	94/60	134/76	372 days
F M	90/56	134/98	370 days
J Z	94/52	136/92	363 days
A S	110/70	145/95	328 days
J S	92/70	140/90	290 days
J H	98/60	130/90	271 days
D B	108/68	135/85	261 days
I B	110/74	150/98	234 days
S W	120/76	124/78	207 days
R W	108/70	126/76	181 days
Y E	102/74	140/90	157 days
W B	90/55	122/76	150 days
R M	98/60	136/112	123 days
F H	95/54	130/90	65 days

* Detailed protocols of the first six patients have been reported in the Bulletin of the Johns Hopkins Hospital,¹¹ and a comprehensive report of the entire group is in the process of publication

Before leaving the subject it is important to sound a word of warning concerning the use of desoxy-corticosterone acetate. Since the rate of absorption depends upon the consistency and surface area of the pellets, one can easily imagine that improperly prepared pellets might crumble. This accident would result in a rapid absorption of a large amount of this potent hormone. Furthermore, it is wise to remember that many of the patients suffering from Addison's disease are really very sick, and the mere introduction of pellets is not sufficient in their case. They should be under careful supervision for at least two weeks after the implantation of the pellets. At present, the Government has not authorized the sale of desoxy-corticosterone acetate, nor has it been accepted by the Council on Pharmacy and Chemistry of the American Medical Association.

REFERENCES

- ¹ Addison, T. On the Constitutional and Local Effects of Disease of the Suprarenal Capsules. London, 1855.
- ² Greenhow, E. H. Addison's Disease. *Lancet*, **1**, 1875.
- ³ Oliver, G., and Schaefer, E. A. *Jour. Physiol.*, **18**, 230, 1895.
- ⁴ Pfiffner, J. J., and Swingle, W. W. *Anat. Rec.*, **44**, 225, 1929, and *Science*, **71**, 321, 1930.
- ⁵ Snell, A. M. *Internat. Clin.*, **3**, 46, 1934.
- ⁶ Loeb, R. F. *Proc. Soc. Exper. Biol. and Med.*, **30**, 808, 1933.
- ⁷ Truszkowski, R., and Zwemer, R. L. *Biochem. Jour.*, **30**, 1345, 1936.
- ⁸ Steiger, M., and Reichstein, T. *Helvet. chim. acta*, **20**, 1164, 1937.
- ⁹ Reichstein, T., and von Euw, J. *Helvet. chim. acta*, **21**, 1197, 1938.
- ¹⁰ Thorn, G. W., and Eisenberg, H. *Endocrinology*, **25**, 39, 1939.
- ¹¹ Thorn, G. W., *et al.* *Bull. Johns Hopkins Hosp.*, **44**, 339, 1939.

DISCUSSION.—DR. HARVEY STONE (Baltimore, Md.) I think everyone here must have been impressed, first, with the masterly presentation by Doctor Firor of this important subject and the clear historic review of the sequence of development up to the present time. I am sure also we are impressed with this great addition to the therapeutic possibilities of treatment of deficiency disease by this new method, and I think we can all gather a lesson from it that advance at the present time in the complicated problems surgery now presents requires the concerted efforts of the physiologist, chemist and surgeon working together. It is no longer a question of a man working by himself with any hope of success. Doctor Firor has played an important part in this sequence of development.

I should like to refer to some work Doctor Owings and myself have carried on along somewhat similar lines. A few years ago we presented before this Association some experimental work in the transplant of living endocrine organs. At that time we were entirely concerned with the thyroid and parathyroid. Since then we have continued with that work, and this may be a favorable opportunity to make a brief report of our very scanty efforts in transplant of the adrenal cortex. We have done three cases. Without going into detail, two of these cases showed notable and definite improvement. One lived for nine months after transplant and was able to return to work, following a rise of blood pressure comparable to those reported by Doctor Firor. He died of pulmonary tuberculosis. A second patient lived for two and one-half years after the first transplant, and was able to return to work with a com-

parable rise of blood pressure similar to those reported by Doctor Frior. At the end of about two years he showed some failure of improvement and came back for a second graft, was again improved and about half a year later acquired an acute influenzal pneumonia and died. On the third case we are not able to present much information. The patient left Baltimore and we lost track of him. We know he died a number of months later and we have nothing to say about the improvement, as to whether it was marked or not.

So far as the immediate effect of the graft is concerned, I think it is no better than pellet implantation of synthetic hormone which Doctor Frior discusses, and it may be that improvement in these cases was not so much due to the success of the graft as to the slow release of the hormone in the grafted tissue. It is difficult for me to assume that we grafted sufficient tissue to give improvement for two years, and the evidence suggests that the grafts survive for a certain period of time and then disappear.

One last word. This work still falls short of the ideal in supplying the patient with a living graft which will not need replacement as is obviously necessary with the pellet method of Doctor Frior, and I think everyone will agree the ideal remedy would be something that will last as long as the recipient survives.

DR GEORGE J HEUER (New York, N. Y.) I also should like to congratulate Doctor Frior on his splendid piece of experimental and clinical research. I am not sufficiently familiar with the subject to discuss it, but I would like to know whether Doctor Frior has observed any ill effects from implanting the pellets in the tissues or whether he anticipates any danger from their use.

DR WARFIELD M. FIROR (Baltimore, Md., in closing) I am glad Doctor Heuer asked that question. There is a real danger in this form of treatment, inasmuch as the rate of absorption depends upon the consistency of the pellet, if one uses a soft pellet that crumbles easily, a patient will absorb an enormous amount of this potent hormone very quickly. We have had such a case called to our attention. The patient's blood pressure went to 200 and there were signs of impending cardiac failure. The patient came to Baltimore and I had to take out most of the pellets because this patient, having received soft pellets, was absorbing them too rapidly. One has to be very cautious, and we do not allow any of these patients to go home until they have been in the hospital for about two or three weeks after the pellets have been implanted. In one woman the absorption rate was too rapid, and I took out two of the 12 pellets I had put in before I let her return home. We do not feel that this form of treatment is ready for general use, and we are not absolutely certain that we have determined the best way of sterilizing these pellets.

We dissolve the hormone in hot acetone and then pass it through a Seitz filter. The pellets are autoclaved at low pressure and finally washed in ether just before implantation. The Ciba Company, which has undertaken the preparation, has had a little difficulty in making pellets of uniform consistency. The Government will not permit desoxy-corticosterone acetate to be released, and the Committee on Pharmacy of the American Medical Association has not yet given its approval that this substance is a standard substitute for adrenal insufficiency.

CYSTS, SINUSES AND FISTULAE OF THE THYROGLOSSAL DUCT *

RESULTS IN TWO HUNDRED AND NINETY-THREE SURGICAL CASES

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OF the congenital anomalies commonly encountered in the cervical region, perhaps none have resisted surgical correction for so long a time as have the cysts, sinuses and fistulae arising from a persistent thyroglossal duct. The reasons for this are not altogether clear. Since the nature of the developmental defect has long been well understood and since the problem of treatment offers little technical difficulty, it seems incredible, in retrospect, that surgeons continued to employ with so little success inadequate measures until 1920, when Sistrunk⁴ advised the excision of the entire thyroglossal tract and devised for this purpose a safe and thoroughly satisfactory operation. Sistrunk was not one of the first to perform a radical procedure in these cases. Schlange,³ in 1893, and Durham,¹ in 1894, cognizant of the fact that unsuccessful attempts at cure were due to the incompleteness of the operative removal of the tract, divided and removed a segment of the hyoid bone and dissected the duct to the root of the tongue. Later Ehot,² Spencer⁶ and others advocated similar procedures. However, Sistrunk, recognizing that it is not always possible to trace the upward extension of the tract, even in cases in which the sinus has been injected with methylene blue, devised a procedure that would insure the complete removal of the entire tract and advocated its employment as routine.

A thyroglossal duct cyst is a retention cyst which arises in a patent portion of the vestigial thyroglossal tract and occurs anywhere in the midline along its pathway from the base of the tongue to the region between the hyoid bone and the thyroid gland. Clinically, the site of the cyst is far more common below the level of the hyoid bone than above it. Frequently the cyst ruptures through the skin spontaneously or is incised, an intermittent draining channel which may end blindly in the tissues, that is, a sinus, may result from rupture or the channel may run uninterruptedly to enter the mouth through the foramen caecum, that is, a fistula.

Knowledge of the origin and development of the thyroid gland simplifies the understanding of the surgical treatment of thyroglossal duct cysts. The

* Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

principal, if not the only, primordium of the thyroid gland arises as an evagination or outpocketing in the ventral wall of the primitive pharynx between the first and second pharyngeal pouches. This position is marked in adult life by the foramen caecum at the base of the tongue behind the apex of the "V"-shaped row of the circumvallate papillae. The primitive thyroid structure descends in the midline through tissue which later becomes the hyoid bone. Inasmuch as the hyoid bone develops either simultaneously with, or later than, the descent of the thyroid gland, the thyroglossal duct may vary in its relation to the hyoid bone. The tract lined with epithelium produced by this descent normally disappears between the fifth and eighth weeks of fetal life, but occasionally fails to become obliterated. This failure of obliteration of either a portion of, or of the entire, thyroglossal duct subsequently may lead to the formation of a thyroglossal duct cyst, sinus and rarely a fistula (Fig 1).

The majority of operations for the treatment of these conditions are unsuccessful unless the entire tract running from the cyst to the foramen caecum is removed. Since Sistrunk^{1, 2} proposed this operative technic for radical removal of a thyroglossal duct cyst and its tract in 1920, his operative procedure has been employed in the surgical management of the majority of the cases at the Mayo Clinic. The operation as proposed by Sistrunk and employed by us, with a certain few minor modifications, is as follows:

Under general anesthesia, a transverse incision two or three inches (5 to 7.5 cm) in length is made at about the level of the hyoid bone (Fig 2, inset). When a sinus is present it may be injected with methylene blue to outline its course and an elliptic transverse incision made to include the sinus. The skin, subcutaneous tissue, and platysma muscle are reflected. The cyst or sinus tract will usually be found lying on the thyrohyoid membrane. It is dissected free from the surrounding tissues up to the hyoid bone. The relation of the tract to the hyoid bone is variable, usually passing through or beneath the bone, but occasionally passing above it. For this reason, to insure complete removal of the tract at this point and to facilitate exposure above this point, the central portion of the hyoid bone is freed above and below and the midportion, measuring about one-quarter inch (0.63 cm) in length, is removed with bone forceps. As a rule the dissection up to this point is carried out without great difficulty, but above this the tract is usually so small and friable that it is broken off easily and is difficult to remove. For this reason no attempt is made to isolate the tract, but the duct and tissues surrounding it for a distance of 3 or 4 cm on all sides are coiled out through the muscles of the tongue to the foramen caecum (Fig 2). This can be done without difficulty as Sistrunk has shown that the pathway of the duct corresponds to a line drawn at an angle of 45 degrees backward and upward through the point of intersection of lines drawn horizontal and perpendicular to the center of the hyoid bone (Fig 1). This dissection can be facilitated by placing the index finger of the left hand in the patient's mouth and pushing the foramen caecum upward and forward (Fig 3). A portion of the hyoid bone, portions of the raphe of the mylohyoid muscles, and portions of the

geniohyoid and genioglossus muscles are removed. In cases in which the duct is patent above the hyoid bone the foramen caecum is also removed (Fig 4)

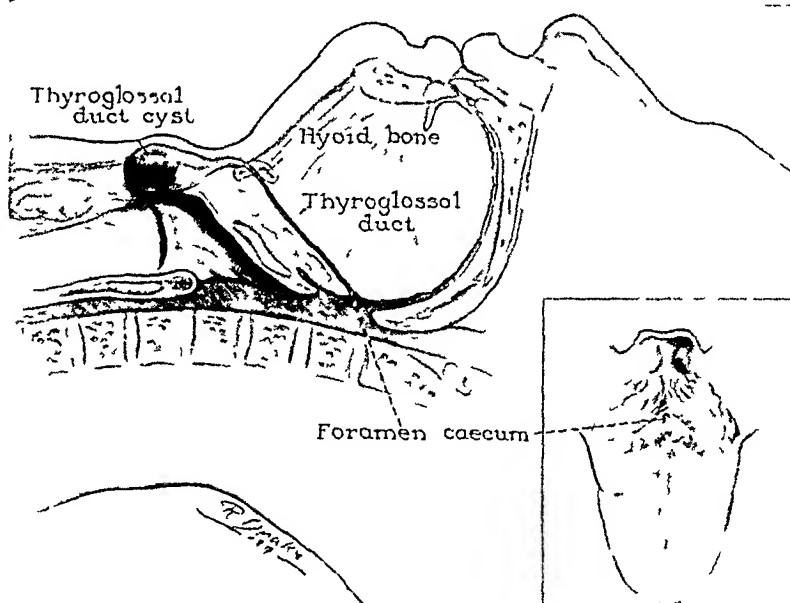


FIG 1—Sagittal section of head showing position of thyroglossal duct
Inset Dorsum of tongue with foramen caecum

but in others in which the cyst seems to be confined entirely to the subhyoid region it has been satisfactory to stop the dissection just at the foramen caecum

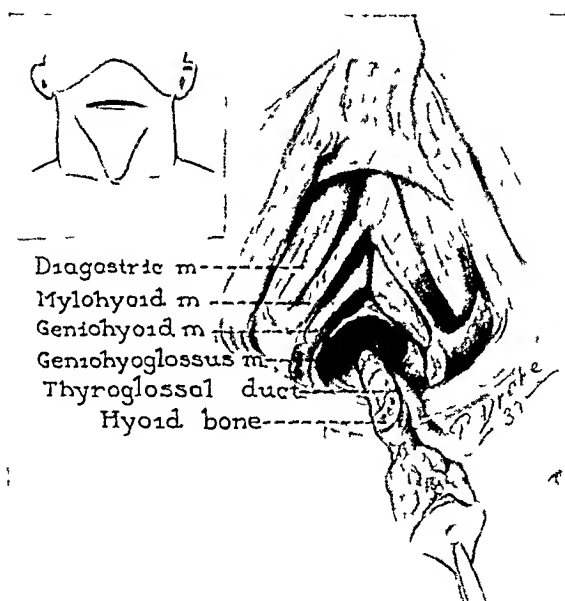


FIG 2—Dissection of thyroglossal duct tract. A segment of hyoid bone has been removed and duct with surrounding tissue is dissected through the muscles of the tongue. Inset The incision

without removing it and consequently without actually entering the mouth. There is, however, no serious objection to entering the mouth. The opening

PERSISTENT THYROGLOSSAL DUCT

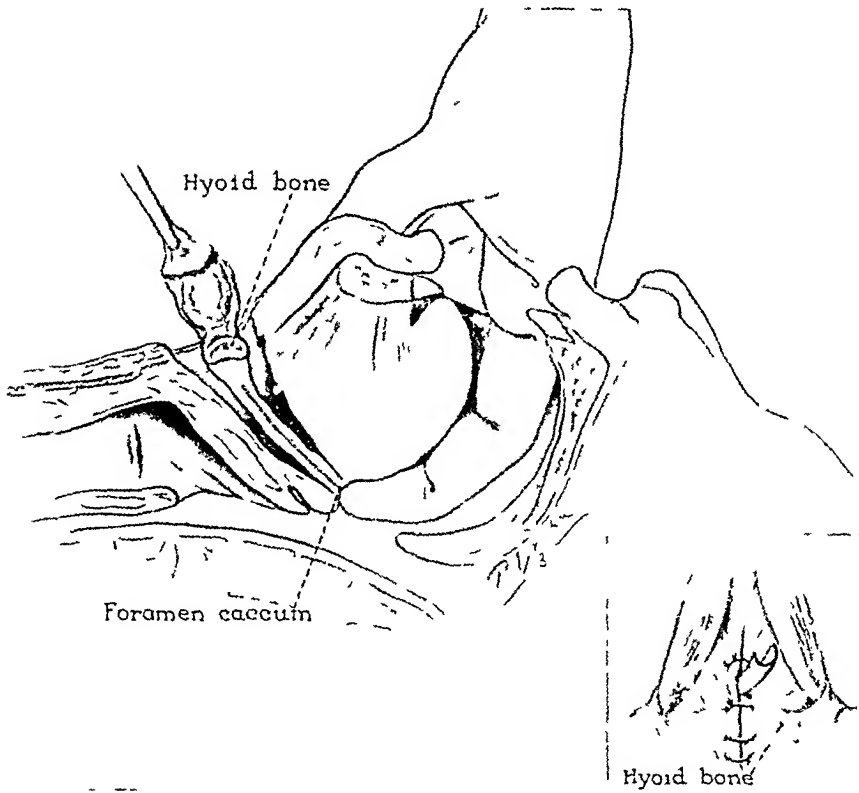


FIG 3—Finger in mouth locating foramen caecum and elevating tract
Inset Closure of wound

through the muscles of the tongue is closed with interrupted sutures of catgut placed superficially to avoid the hypoglossal nerves. The edges of the hyoid bone are brought together with stitches through the periosteum (Fig 3,

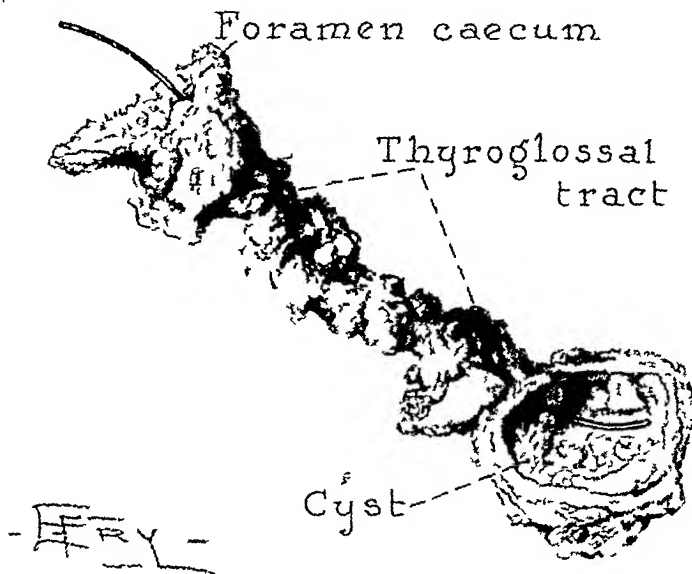


FIG 4—Excised thyroglossal duct fistula

inset) A small rubber tube drain is placed deep in the muscles of the tongue and the skin wound is closed with interrupted dermal sutures.

From the years 1920 to 1938, inclusive, this operation has been performed at the Mayo Clinic in 293 consecutive cases. The sex incidence of the

patients was two males to one female. Operation was performed upon only 32 patients who were less than ten years of age. One hundred forty-four patients were between the ages of ten and 40, 90 were between 30 and 50 years, and only 27 beyond the age of 60 when the Sistrunk operation was performed at the clinic. The cyst or sinus had been noticeably present in some patients since birth, whereas in others it was present from a few weeks to even years. A summary of data on the age at time of operation at the clinic and the sex of the 293 patients is given in Table I.

TABLE I
AGE AND SEX

Sex	Number	Per Cent	Age in Years		
			Mean	Youngest	Oldest
Males	194	66.2	28.4	3	66
Females	99	33.8	25.1	4	58
Total	293	100.0	27.3	3	66

We were able to definitely trace as to recurrences, either by means of a questionnaire or by examination, 261 (89.1 per cent) of the 293 cases. In 166 (63.6 per cent) of these 261 cases, operations, usually multiple, had been performed prior to the patient's admission. Several of these patients had had from three to ten operations. In 41 of them the operative procedure was limited to incision and drainage, whereas in 125 at least one previous attempt had been made to excise the thyroglossal tract. In addition, in some instances the duct had been curetted or cauterized with electric cautery, carbolic acid, and other caustics. Frequently surgical therapy was supplemented by either roentgenotherapy, radium or both. In several cases ultraviolet irradiation, diathermy, and iodine both externally and internally had been administered. The operation in this group of patients presented considerable technical difficulty. Data on the recurrence of the sinus, cyst or fistula in the 261 traced cases are given in Table II.

TABLE II
RECURRENCE FOLLOWING OPERATION

	Total Cases *	Recurrences	
		Cases	Per Cent
Previous surgical measures	166	3	1.81
No previous surgical measures	95	1	1.05
Total	261	4	1.5

* Only 261 cases (89.1 per cent of the total 293 cases) were definitely traced as to recurrences included in this table.

There were only four recurrences in the entire group of 261 traced cases. The only patient who had recurrence in the group who had not had a previous operation was a man, 43 years of age. He had noted the thyroglossal duct cyst during his youth and was one of the first patients operated upon, using this method in 1920. Shortly after the operation, recurrence was noted.

The three patients who had undergone surgical procedures prior to the

Sistrunk operation performed at the clinic and had recurrence are interesting. The cyst of one patient, a man aged 31 years, had been noticed when he was two years old. It had been incised on many occasions, cauterized with carbolic acid on others, and a radical surgical excision attempted on two others. When the Sistrunk operation was performed at the clinic, the enormous amount of scarring and resulting deformity made a satisfactory operation impossible. Recurrence took place a few months after this operation. We recently have operated upon this patient again and, we feel, with much greater success. The second patient, a man aged 34 years, had noticed the cyst at the age of 17. This was incised several times and two attempts at radical removal were made elsewhere. The recurrence took place shortly after the operation performed at the clinic. The third patient, a youth of 18 years, had the cyst at the age of 19 months. It had been incised on several occasions and three attempts at radical removal had been made. When we first saw the patient the cyst was acutely inflamed, so it was opened and drained, and a few days later, in spite of the fact that the inflammation had not subsided, an attempt at radical removal was made. The tissues were so fragile and inflamed that the operation was exceedingly difficult. Recurrence took place within a few weeks following the operation. In the last two cases recent operation for these recurrences has been performed successfully.

COMMENT —The effectiveness of the operation as proposed by Sistrunk for the complete removal of a thyroglossal duct cyst, sinus, or fistula is well established by the aforementioned results.^{4, 5} Recurrences for the most part can be attributed to the presence of extensive scarring and various degrees of infection as a result of previous surgery. We feel that one of the recurrences in our series could possibly have been avoided and that recurrences in general can be avoided if the radical operation is postponed until the presence of acute infection has subsided. In cases in which there is considerable surrounding inflammation, it is usually best to make a simple incision and then several weeks after the inflammation has subsided completely perform the radical operation. Certainly, a thyroglossal duct cyst should not be incised unless inflammation is present for an unopened cyst makes the operation technically less difficult. When incision and drainage is performed, it should be undertaken only with the understanding that later radical excision will be necessary for cure. We have found, as Sistrunk has pointed out, that the injection of some dye, such as methylene blue, facilitates the tracing of the tract and aids in the detection of lateral branches in cases in which the cyst either has ruptured or has been previously treated surgically. In a few instances in which the cyst and its attachment have ended at the hyoid bone, because of a complete obliteration of the portion of the tract between the hyoid bone and the tongue the dissection was not carried through the muscle of the tongue. Thus the opening into the mouth with its resultant discomfort for the patient was avoided. In none of these instances has there been any evidence of recurrence. We realize that a sufficiently long period has not elapsed in all cases to exclude all possibility of a recurrence, but it has been our experience that recurrences which are due to incomplete removal of the

tract usually take place relatively soon after operation. In a few isolated instances they have occurred a few years after operation, but these have been exceptionally rare and for this reason we feel reasonably certain in our analysis of these cases. Only cases which were checked carefully either by a follow-up letter or by recent examination at the clinic were included in the study.

SUMMARY

A series of 293 cases of thyroglossal duct cyst in which the Sistrunk operation was employed were reviewed. Two hundred sixty-one of these cases were satisfactorily traced as to the possibility of recurrence. There were four recurrences in this series. The recurrences for the most part can be attributed to the presence of extensive scarring and infection as a result of previous surgery. The effectiveness of the Sistrunk operation stands out in sharp contrast with the many failures common to the less radical procedures.

REFERENCES

- ¹ Durham, H. E. On Persistence of the Thyroglossal Duct, With Remarks on Median Cervical Fistulae and Cysts Due to Embryonic Remnants. *Tr. Med-Chir. Soc.*, London, 77, 199-228, 1894.
- ² Eliot. Quoted by Neris, G. R. *Le tractus thyroglosse*. Gaston Doin & Cie, Paris, 1929, pp. 170.
- ³ Schlange, H. *Über die Fistula colli congenita*. *Arch. f. klin. Chir.*, 46, 390-392, 1893.
- ⁴ Sistrunk, W. E. The Surgical Treatment of Cysts of the Thyroglossal Tract. *ANNALS OF SURGERY*, 71, 121-122, January, 1920.
- ⁵ Sistrunk, W. E. Technic of Removal of Cysts and Sinuses of the Thyroglossal Duct. *Surg., Gynec. and Obstet.*, 46, 109-112, January, 1928.
- ⁶ Spencer, W. G. The Thyroglossal Tract. *Lancet*, 1, 522-524, February 21, 1914.

DISCUSSION—DR FRANK H. LAHEY (Boston, Mass.) I have been much interested in this very valuable paper. I think we must all agree that it was not until Doctor Sistrunk called attention to the necessity of removing the central section of the hyoid, excising the thyroglossal tract up to the tongue, that we began to get good results in cases of thyroglossal cysts. Probably we have all had the same experience when we first performed the operation. The percentage of recurrences was high, but since performing this radical operation the percentage of recurrences has been zero. We have operated upon about 200 patients with similar results.

There are a few things to be said regarding the operation. The tract cannot be traced above the hyoid in most cases. In certain cases there are collar-button tracts above and below and the tract can be well brought out. A central block of tissue must be taken out up to the base of the tongue. One does not have to be warned about the disadvantage of the longitudinal incision. One has only to see such an incision to know how terrible it is. It makes a checkrein running down the chin to the hyoid which is extremely difficult if not impossible to correct. I think one must be careful in excising the central portion of the hyoid bone to get an adequately wide removal. We were, in the beginning, disturbed because we could not resuture the hyoid, but this is not necessary. In a great many cases no attempt is made to do anything but suture the muscle.

As Doctor Pemberton has said, the thyroglossal tract represents the course along which the thyroid gland descends from its origin at the base of the tongue. Occasionally the thyroid gland does not descend and one then has what is called a lingual thyroid. We have had three patients with this condition in which all of the thyroid gland occurred as a mass of tissue at the

base of the tongue and so interfered with swallowing, as it continued to grow in size, that it required removal. Our experience with these lingual thyroids, related as they are to the descent or nondescent of the thyroid, may be of interest. We have never attempted to remove one of these lingual thyroids through the neck. I think it is the wrong way. In all three of these cases the lingual thyroids have been successfully removed through the mouth. One must remember also that probably all these patients will be myxedematous after removal of the lingual thyroids since they represent all of the thyroid present. The mouth is widely dilated and silk traction stitches are placed on each side of the tongue. It is extremely important that these stitches be inserted well back in the tongue so that the tongue can be pulled out to the forward portion of the mouth where the lingual thyroid can be dealt with under direct vision. I undertook the first one of these cases with considerable trepidation. I feared that the bleeding would not be easy to control. The dissection of the thyroid at the root of the tongue can be done very satisfactorily by splitting the tongue. The mass can be removed without difficulty, bleeding can be controlled and when all the vessels have been ligated, the tongue can be quite accurately approximated. Lingual thyroids are quite rare but one should have in mind their possible presence if a tumor is found on the back of the tongue and in the region of the foramen cecum.

DR HAROLD L. FOSS (Danville, Pa.) It was not completely clear to me, from Doctor Pemberton's paper and Doctor Lahey's discussion, whether, routinely, the hyoid is divided by them or, especially, in what percentage of cases a segment of hyoid is excised. We have had several recurrences in my own clinic even with resection of the hyoid bone. Of course, a most complete excision of the entire tract must be carried out, as was pointed out by Sistrunk and to-day emphasized by Doctor Pemberton. It has been many years since I assisted the late Dr. Walter Sistrunk, and years since I read his original paper. In all probability he advised, for completeness' sake, removing a segment of the hyoid along with the entire fistulous tract, but I have forgotten. Doctor Pemberton will enlighten us, I am sure.

DR VILRAY P. BLAIR (St. Louis, Mo.) In regard to the points made by Doctor Lahey, I once made a total excision of a lingual thyroid gland and decided that in future I would remove but part of the protrusion and save the necessity of subsequent thyroid gland extract treatment.

DR J. DEJ. PEMBERTON (Rochester, Minn., in closing) In regard to the lingual thyroid, I want to say that I think Doctor Lahey has brought out a very important point. The success of the operation on lingual thyroid is dependent on adequate exposure and this can be obtained best by means of traction sutures on the tongue. If intratracheal anesthesia is used, the operation is not difficult, since the bleeding can be controlled by suturing.

Doctor Foss asked if we removed a section of the hyoid bone routinely. We do, since at this point the thyroglossal duct cannot be visualized, in order to be sure that complete dissection is carried out, the central segment of the hyoid bone must be removed, as the duct sometimes runs through the bone itself. I think that we owe a great deal to Doctor Sistrunk for his efforts in standardizing this operation. As you know, up to his time, the medical profession looked on these sinuses in the light of a surgical rat hole, that is, they were annoying and troublesome to the patient but they were not dangerous to health. Therefore, no one took pains to devise a satisfactory operation for their removal.

RESULTS OF FACIO-HYPOGLOSSAL ANASTOMOSIS IN THE TREATMENT OF FACIAL PARALYSIS*

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SURGERY of the facial nerve may be required for the restoration of function when the nerve is paralyzed from trauma or disease¹ and to reduce or abolish function when the muscles it supplies are involved in severe spasm. In a paper² before this Association in 1936, attention was called to the paroxysmal disturbance of function characteristic of surgical diseases of the cranial nerves. In addition to the facial, other cranial nerves showing explosive disturbance of function are the fifth and ninth in intractable neuralgia, the eighth in Ménière's disease, and the eleventh in spasmodic torticollis. Destructive operation upon the affected nerve is required for the relief of these conditions. Operation upon the facial nerve is resorted to in a large majority of cases to restore function, and in this respect surgery of the facial nerve differs from that of other cranial nerves in which the operation is always destructive.

The deformity caused by severe facial paralysis is too familiar to require description but an analysis of the components of this deformity may be of some interest. The most conspicuous and embarrassing feature of the deformity of unilateral facial paralysis arises from displacement of the mouth by unopposed contraction of the muscles of the healthy side, whereas the alteration of facial appearance caused by paralysis of other muscle groups, such as those of the upper lip, eyelids and brow, is not exaggerated by the activity of the muscles on the normal side (Fig. 1). From loss of function of the mandibular branch of the nerve there is not only sagging and deviation of the lips when the face is in repose but emotional expression on the healthy side draws the mouth out of alignment and suddenly produces a marked increase in the deformity. From observation of patients upon whom section of the upper branches of the nerve had been performed for the relief of facial spasm or in cases of accidental division of these branches, we have been greatly impressed with the slight facial deformity resulting from loss of action in the muscles of the upper part of the face when balance of the mouth is retained by action of the lower branch of the nerve (Figs. 2 and 3). There may be sagging of the lower eyelid from loss of innervation to the orbicularis oculi but this is not a conspicuous deformity and may be greatly improved by external canthoplasty.

Decompression of the nerve in the bony canal, direct suture and nerve

* Read before the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

graft have been enthusiastically advocated for lesions in or peripheral to the bony canal and these reconstructive operations will probably supersede anastomosis when the location of the lesion is favorable for such procedures. In my observation of the results of suture and graft of the trunk of the facial nerve I have been impressed with the failure of these operations to restore emotional expression or to prevent mass movements of the face. The development of mass movements of the face and the permanent loss of normal emotional expression after nerve graft or suture are due to defective regeneration of the nerve. Following severe paralysis, regeneration of the facial nerve, whether spontaneous or aided by suture or graft, proceeds with some disorder of the regenerating fibers and with deflection of the new fibers from the course they normally follow. Ford and Woodhall,⁴ in a very interesting paper, have discussed the effects of misdirection of regenerating nerve fibers upon the subsequent action of the facial muscles. After section or a severe degenerative lesion of the nerve, new fibers from that part of the nerve normally intended for one group of muscles may penetrate every muscle group within the facial domain, thus preventing the isolated action of individual muscle groups so essential to emotional expression. The result is that when the patient attempts to close the eye, the muscles about the mouth contract and efforts at expression by action of the muscles about the mouth are accompanied by associated contraction of the orbicularis oculi. While it is possible in operation for direct suture to preserve the nerve pattern in a gross way, straying and deflection of the new fibers cannot be prevented. This phenomenon of faulty regeneration fully explains the failure of any surgical procedure to restore normal movements of the face and emotional expression after severe lesions of the trunk of the nerve. The situation is altogether different after successful repair of one or more peripheral branches of the facial nerve. In such cases the misdirection of fibers of the regenerating nerve would affect only the group of muscles normally supplied by that branch of the nerve and would not mar facial ex-



FIG. 1.—Facial paralysis with marked atrophy and deformity following complete removal of a left acoustic neuroma two years previously. Patient's general and neurologic condition excellent with exception of facial paralysis. Typical deformity of complete facial paralysis when atrophy of the muscles has taken place. No response to galvanic stimulation on affected side. Anastomosis not indicated. Operation for support of the face by fascial strips after Brown's method November 9, 1939, with immediate improvement in patient's appearance. Operation too recent for postoperative photographs. Photograph used to illustrate severe progressive deformity when innervation of facial muscles is permanently destroyed.

pression. The results of suture of important branches of the nerve are highly successful from every standpoint.

While several surgical procedures are in common use for the relief of deformity resulting from severe facial paralysis, anastomosis of the facial with another motor cranial nerve is the only procedure which will restore innervation to the paralyzed facial muscles following an intracranial lesion of

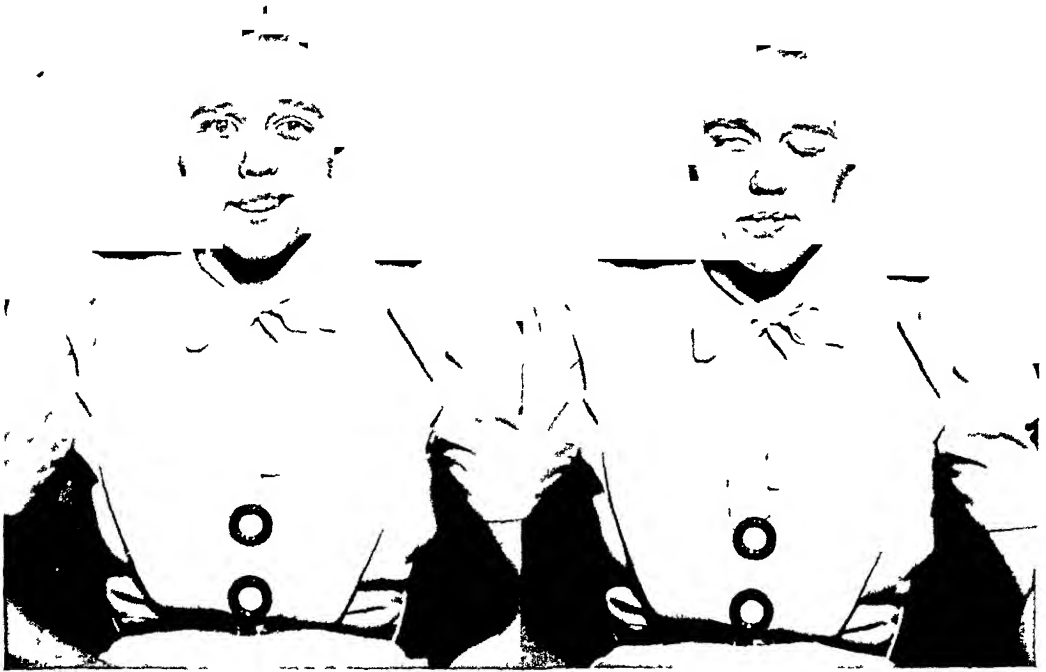


FIG 2—Paralysis of the upper branches of the facial nerve caused by a glass wound in the parotid region. As is usual in such cases the mandibular branch of the nerve escaped injury. Photograph illustrates the important part played by the mandibular branch of the nerve in the preservation of facial symmetry. Even in smiling, the mouth is fairly well balanced although there is slight droop of the upper lip. Some widening of the palpebral fissure is shown. Suture of the individual branches of the nerve November 2, 1939, two months after injury. Evidence of returning function expected in about three and one half months after operation.

FIG 3—Patient shown in Fig 2 showing inability to close eye on the affected side. If it is impossible to repair the branches of the nerve to the muscles about the eye, considerable improvement may be obtained from canthoplasty.

the nerve. There can be no adequate substitute for anastomosis in such cases. Intracranial injuries of the facial nerve formerly were rare but now are frequently seen due to the increasing number of operations for cerebellopontine angle tumor, with destruction of the facial nerve by complete removal of the tumor and its capsule (Figs 4, 5 and 6).

When anastomosis is required for innervation of the paralyzed facial musculature we have preferred the hypoglossal to the spinal accessory because of its functional similarity to the facial. Facio-hypoglossal anastomosis will restore movement to the paralyzed muscles in practically every case, will

balance the face in repose and prevent atrophy of the muscles on the affected side. These results fully justify this type of surgical procedure for the improvement of a deformity which without operation becomes progressively worse (Figs 7, 8, 9 and 10). Function of the muscle groups cannot be individualized after facio-hypoglossal anastomosis, and when the patient responds to emotional stimuli the expression of emotion is registered only on the healthy side. Smiling is accompanied by slight deviation of the mouth to the normal side due to delayed action and weakness of the muscles about the mouth on the affected side. Frontalis action has been recovered in only one case in our series after hypoglossal anastomosis. The loquacious patient is the most unfavorable type for facio-hypoglossal anastomosis, and in such patients the spinal accessory might be used. There is a marked difference in the activity of patients' tongues, not only with respect to talking but also when swallowing. Associated movements of the face are produced by action of the tongue after hypoglossal anastomosis. In some patients in whom the movements of the tongue during swallowing or talking are very active, there are exaggerated contractions of the muscles about the eye and lips, giving the patient in an extreme case a grotesque expression. Success of anastomosis operations depends to a great extent upon the patient himself.

Results of facio-hypoglossal anastomosis compare favorably with those of suture or graft of the nerve trunk, but anastomosis requires the sacrifice of another cranial nerve and if the hypoglossal is used it necessitates control of the movements of the tongue to minimize associated movements. Atrophy of the tongue caused by section of the hypoglossal appears to be of no important significance and causes no appreciable interference with speech or deglutition (Figs 11, 12 and 13).

Much has been said about reeducation of the patient who recovers function of the muscles following operation for facial paralysis. It is difficult to understand how such reeducation could be very successful when directed only to improvement of action of the previously paralyzed muscles. Accepting the experimental evidence of regeneration of the nerve and the phenomena of deflection of axis cylinders from normal pathways, one can readily appreciate



FIG 4—Complete left facial paralysis following total removal of an acoustic neuroma. There was also injury to the left trigeminal nerve. The lids have been sutured to protect the eye. Left facio-hypoglossal anastomosis, March 8, 1937, to relieve the paralysis.

the obstacles to reeducation. With misdirection and deflection of regenerating axis cylinders the entire facial musculature on the affected side is made a single functional unit and the facial muscles move *en masse*. It seems impossible for reeducation, under such circumstances, to effect materially a dissociation of action of various muscle groups. In some cases efforts at reeducation may result in increasing the patient's deformity by bringing about overactivity of the affected side, causing grimaces which may become habitual. We believe that much more can be accomplished in improving the results of operation by instructing the patient to suppress facial movements and



FIG 5—Photograph of the patient in Figure 4 21 months after anastomosis. Recovery of motion in all muscle groups except the frontalis and platysma. No deformity is evident when the face is in repose.



FIG 6—Photograph of the patient shown in Figures 4 and 5 shown closing the eyes with little associated movement. Atrophy of the muscles of mastication caused by injury to the trigeminal nerve when the tumor was removed.

emotional expression on the normal side. Suppression of facial movements should become a fixed habit.

The residual effects of facial paralysis after maximum recovery of function following anastomosis operations, obviously, will vary in importance according to the patient's occupation, age, sex and social position. One must give serious consideration to the unavoidable destruction of the facial nerve in operations for the complete removal of acoustic tumors. The patient should be fully informed before operation is undertaken that complete removal of an angle tumor is almost inevitably followed by facial paralysis and he is entitled to know in detail the features of such paralysis. In only one case have we been able to completely remove an acoustic neuroma without destroying the facial nerve (Figs 14 and 15). Facial paralysis is a small sacrifice to make

for the assurance of permanent eradication of an acoustic neuroma as a primary procedure especially when one reflects that operations for recurrence of these tumors following incomplete removal are highly dangerous and may be impossible. The argument for a more conservative type of operation for acoustic neuroma is strengthened in certain cases by the fact that the tumor is a benign one, and after complete enucleation of the tumor with almost complete removal of the capsule, recurrence probably would not take place for a great many years.



FIG 7—Results of facio hypoglossal anastomosis for relief of facial paralysis following complete removal of a left acoustic neuroma. Tumor symptoms completely relieved by operation and the patient is actively engaged in his work. Photograph shows the face in repose. The mouth is well balanced, there is little difference in the width of the palpebral fissures and very slight alteration of the patient's facial appearance. Photograph two years after anastomosis.

FIG 8—Photograph of the patient in Figure 7 showing limitation of emotional expression with some weakness of the left side of the mouth. The functional results of the operation in this case were highly satisfactory.

When there is residual paralysis or incomplete recovery of important muscle groups the patient's appearance may be improved by supporting the face with fascial strips, as described by Brown,⁵ in 1938, and stabilizing the paralyzed side in this manner is the only operation that will improve the deformity when the facial muscles have lost galvanic response or when there is extensive destruction of peripheral branches of the nerve. In many cases the combination of nerve anastomosis and fascial support gives the best results, and we believe this combination of surgical procedures should be employed more frequently.

Facio-hypoglossal anastomosis is an operation of little difficulty and negligible risk. An incision is made extending from the tip of the mastoid process downward, following a crease in the neck about 2 cm beneath the mandible, extending in the direction of the thyroid cartilage (Fig 16). The hypoglossal nerve is first isolated at the level of the cornu of the hyoid bone and traced backward to where it curves around the occipital artery, but it is not sectioned until the facial trunk has been identified and divided. Exposure of the facial nerve in the digastric fossa is accomplished very easily by retracting



FIG 9—Photograph of the patient in Figures 7 and 8 showing mass movements of the face on the left side when efforts are made to forcibly retract the angle of the mouth on that side. No evidence of frontalis function.



FIG 10—Photograph of the patient in Figures 7, 8 and 9, showing closing of the eyes, which is accompanied by movements of the muscles about the mouth. Photograph one year after anastomosis.

the digastric muscle downward and following the digastric branch of the facial upward to the trunk. Section of the facial trunk is made as close as possible to the stylomastoid foramen. The branches to both the stylohyoid and the digastric muscles are sacrificed but the resulting paralysis is apparently not of great importance, although it may account for some difficulty in swallowing. After division of the facial the peripheral stump is pulled downward and placed in a suitable position for suture. The hypoglossal is then sectioned sufficiently close to the tongue to permit the central segment to be approximated with the trunk of the facial without tension (Fig 17). This requires section of the thyrohyoid branch of the hypoglossal and in some cases it is impossible to approximate the ends of the two nerves satisfactorily without freeing the descendens hypoglossi from the main trunk of the nerve. Anas-



Fig. 11—Marked facial paralysis produced by section of the nerve for the cure of left facial spasm. Section with immediate suture of the upper branches of the nerve had produced temporary relief of the spasm with recurrence. Faciohypoglossal anastomosis for relief of the paralysis.

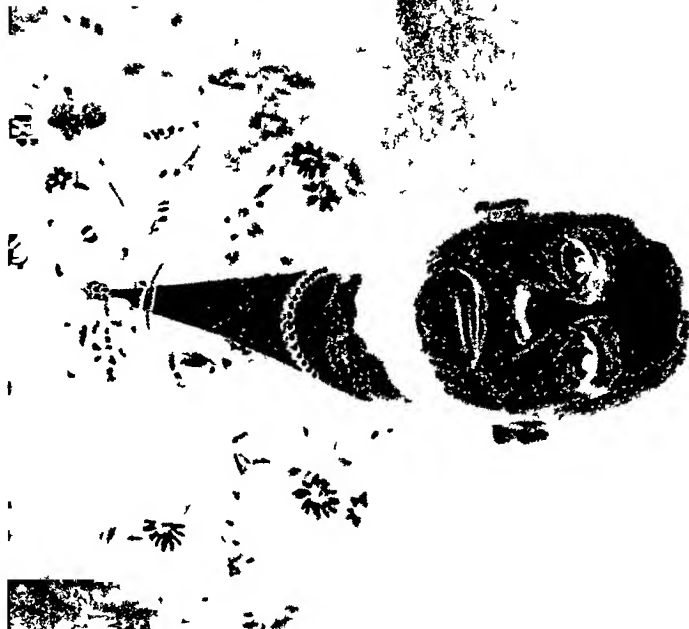


Fig. 12—Photograph of the patient shown in Fig. 11, two and one-half years after faciohypoglossal anastomosis. Very little deformity with face in repose. There was no return of function of the frontalis muscle, but the corrugator on the affected side is active.



Fig. 13—Photograph of the patient in Figures 11 and 12, shown attempting to smile. There is some lagging of the angle of the mouth on the left side and slight widening of the palpebral fissure. The patient's facial expression was normally vivacious and good effects of the operation were somewhat marred by associated movements particularly those about the eye.

tomosis should be performed carefully, with accurate approximation of the nerve sheath and without projection of nerve fibers between the sutures. Three arterial sutures are sufficient to unite the nerves. In some cases we have sutured the proximal end of the descendens hypoglossi to the peripheral end of the hypoglossal trunk. Atrophy of the tongue following this procedure has developed in every case except one, showing that attempts to preserve the

FIG 14

FIG 15



FIGS 14 and 15—Photographs of the patient after recovery from facial paralysis caused by removal of a large left acoustic tumor and its capsule. The intracranial portion of the nerve was greatly lengthened and it was protected during the operation. There was a temporary facial paralysis lasting about six months. The patient was bedridden for some time before operation and was unconscious when admitted to the hospital. She made a complete recovery from tumor symptoms with the resumption of full duties as a school teacher. Photograph three years after removal of tumor. No evidence of impaired facial expression.

trophic supply to the tongue are generally futile. The junction of the anastomosed nerves should be covered by the digastric muscle which is retracted downward during the operation.

The first evidence of returning function of the nerve following anastomosis is improved tone in the paralyzed muscles and the restoration of balance of the mouth. In about three and one-half months feeble movements appear about the angle of the mouth and spread upward to the eye muscles which show definite contraction in about six months. During the stage of paralysis the sagging face should be supported by adhesive strips and the muscle tone preserved as much as possible by facial massage. The maximum improvement is reached after about two years.

Regardless of the type of surgical procedure employed for the relief of complete facial paralysis, one must be impressed with the fact that the maximum recovery following all operations leaves much to be desired, and that the patient's facial appearance is never restored to normal. Facio-hypoglossal anastomosis for the relief of paralysis following intracranial lesions of the nerve will balance the face in repose, restore movement of the paralyzed muscles, and prevent further disfigurement resulting from atrophy of the muscles.

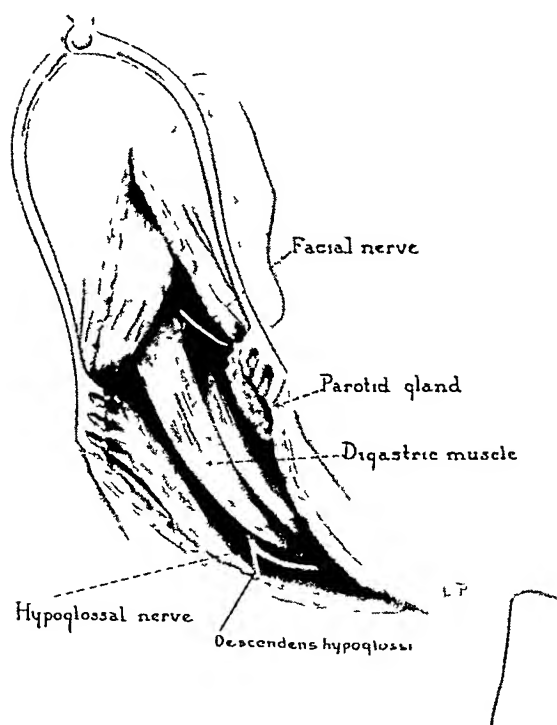


FIG 16—Drawing showing exposure for right faciohypoglossal anastomosis. The sternomastoid muscle is retracted backward. The hypoglossal and the facial nerves are shown. By retracting the digastric muscle downward and backward, a small branch of the facial nerve to this muscle can usually be found. Tracing this branch backward leads to the trunk of the nerve.

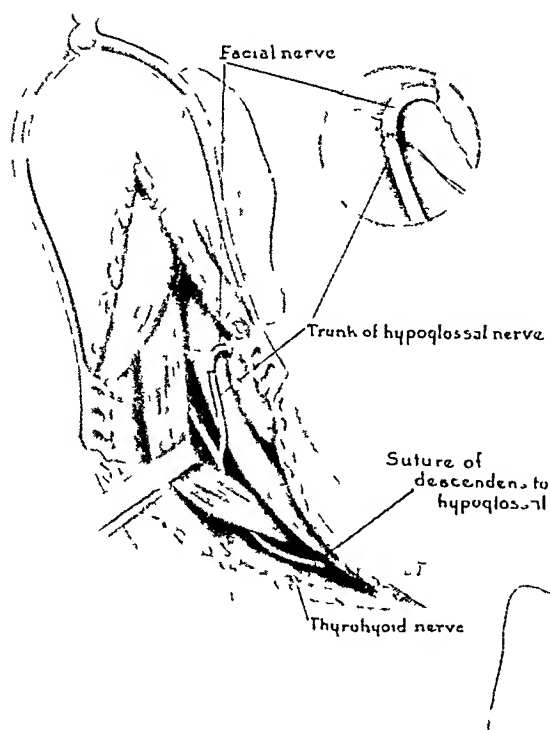


FIG 17—Drawing showing the hypoglossal trunk divided and anastomosed to the peripheral trunk of the facial. The thyrohyoid branch is sacrificed in mobilizing the nerve for suture. The dotted lines show the course of the descendens hypoglossi which has been sutured into the peripheral segment of the hypoglossal nerve. (Redrawn from Facial Spasm, ANNALS OF SURGERY, May, 1937.)

REFERENCES

- ¹ Coleman, Claude C. Surgical Treatment of Facial Paralysis. Trans. Southern Surg. Assn., 1921.
- ² Coleman, Claude C. Surgical Treatment of Facial Spasm. ANNALS OF SURGERY, May, 1937.
- ³ Bunnell, Sterling. Surgical Repair of the Facial Nerve. Arch. Otolaryng., March, 1937.
- ⁴ Ford, Frank R., and Woodhall, Barnes. Phenomena Due to Misdirection of Regenerating Fibers of Cerebral, Spinal and Autonomic Nerves. Arch. of Surg., March, 1938.
- ⁵ Brown, James B. The Utilization of the Temporal Muscle and Fascia in Facial Paralysis. Trans. Southern Surg. Assn., 51, 1938.
- ⁶ Balance, C., and Duel, Arthur B. The Operative Treatment of Facial Palsy. Arch. Otolaryng., January, 1932.
- ⁷ Martin, R. C. Surgical Repair of the Facial Nerve. Arch. Otolaryng., April, 1936.

DISCUSSION—DR CHARLES BAGLEY, JR (Baltimore, Md) Doctor Coleman has presented to us, under the title of "Facial Nerve Surgery," a very interesting group of patients after removal of acoustic nerve tumors. He has done this in his usual modest fashion, with no effort to call attention to the difficulties encountered in the removal of this type of tumor further than to mention the necessary destruction of the facial nerve in the majority of cases. Any tumor in the cerebellar pontine angle is rather inaccessible, so that the operation presents many mechanical difficulties. The actual incorporation of the seventh and eighth nerves in the tumor mass forces one to choose between a subtotal removal or total loss of function of the seventh and eighth nerves on the side of the tumor. In theory, this would seem to be a very simple choice. On the contrary, one always dreads to face a patient whose complete facial paralysis is of his making. Doctor Coleman has, in these cases, attempted to give the patient the advantage of total removal and then to restore the function of the facial nerve.

In this type of paralysis, where one knows the nerve has been destroyed, waiting for spontaneous return is not necessary. Doctor Coleman's plan of repairing the nerve at the earliest possible moment has the advantage of restoring the nerve before damaging atrophy of tissue has advanced too far. The functional results shown by his patients are quite satisfactory at the present time, and, as some of these operations have been performed rather recently, there will be greater improvement as time goes on.

Doctor Coleman is to be congratulated on the very excellent results obtained in a number of patients with complete removal of acoustic nerve tumors in whom he has been able to reestablish facial nerve function so that the price which they have paid for complete removal will ultimately be minimal.

DR JOSEPH E J KING (New York, N Y) I want to congratulate Doctor Coleman on his splendid paper, his management of facial nerve injuries in general, and his fine results in this series. I have always felt that facial nerve injuries should be considered under three headings. First, those in which the nerve is destroyed in its intracranial course, second, that group in which the nerve is injured or destroyed in its course through the temporal bone, and third, those where the injury has occurred in the peripheral portion of the nerve. Therefore, the operation of choice for restoration of the nerve will depend upon the level or point where the nerve is destroyed.

Most of the cases which have come under my observation were those in which the injury was associated with mastoid disease or following mastoidectomy. All of these I have referred to Dr Thomas Tickle for nerve graft. I have done this for three reasons—he has obtained very good results with his cases, there is no scar on the neck, and there is no associated hemiparalysis and atrophy of the tongue.

In those cases in which intracranial destruction has taken place, a graft is out of the question, and in such cases the anastomosis described by Doctor Coleman is naturally the procedure of choice. In cases in which the damage to the nerve is in the peripheral portion, and suture cannot be accomplished, one must resort to fascial strips.

DR FRANK H LAHEY (Boston, Mass) I am sure that this is no place for the general surgeon to enter into a discussion of nerve anastomosis—in our clinic this is the field of the neurosurgeon. On the other hand, I think if we have differences of opinion regarding choice of nerves, we should state them. I have had many opportunities of viewing end-results following injury to hypoglossal nerves, and I am impressed with this as an undesirable situation.

Doctors Poppen and Horrax feel the same way, and, therefore, I may say we prefer to use the spinal accessory nerve. Doctor Poppen has performed most of these operations and, although the functional result has been excellent, the spinal accessory nerve has been chosen in 19 cases and the hypoglossal in one. I have had several cases in which the hypoglossal nerve has been involved in malignancy and its sacrifice has been required. It must be that there is a variation in the degree of dysfunction following paralysis of the hypoglossal nerve. Certainly, in some of my surgical cases I have thought it undesirable to have patients talk with a thick speech and to have difficulty with mastication. You have to question yourself—will you choose to sacrifice the function which has to do with speech and swallowing, or the one which has to do with the last 90 degrees of abduction of the arm, which is the function taken away when the spinal accessory is used in the anastomosis? The last 90 degrees of motion is accomplished by scapular rotation through the accessory innervated trapezius. We have felt that it is better for the patient to lose this last 90 degrees of arm abduction than to have difficulty with speech and swallowing. That may be only a difference of opinion but it has been the conclusion of Doctors Horrax, Poppen and myself.

DR VILRAY P BLAIR (St Louis, Mo.) The most striking feature of this contribution is Doctor Coleman's analysis of the functional results of nerve anastomosis—and that might have something to do with the choice of the repair method. Whether we like the fascial strips or not, most of ours are performed in that way because most of the cases we see are either too old to offer hope of restoring muscle action or the nerve injury has been of small filaments in the parotid gland, and it is practically impossible to make an anastomosis in these. If the fascial strip operation is performed carefully, an almost perfect restoration of the quiescent face will result. Many have tried to obtain muscular motion by turning down a piece of the masseter muscle, but I have never been sufficiently impressed with the procedure to try it. Brown's real contribution was not trying to turn down a piece of muscle which might slough or sclerose but his procedure is to extend the fascia far enough to allow attachment to the undisturbed muscle, which is, I think, the difference between success and probable failure.

DR CLAUDE C COLEMAN (Richmond, Va.) closing. I want to thank Doctors Bagley, King, Blair, and Lahey for their part in the discussion. I agree with Doctor King that nerve graft may be used as a substitute for anastomosis whenever the lesion is favorably situated. Nerve grafts for lesions in the facial canal will not be followed by associated movements but they do not prevent mass movements, and I have never seen a nerve graft restore emotional expression.

In facio-hypoglossal anastomosis, movements of the face are initiated by moving the tongue. Unless action of the tongue is repressed, associated movements of the muscles about the eye may be troublesome. Anastomosis operations, of course, are much simpler than nerve grafts in the facial canal. A thorough knowledge of the surgical anatomy of the temporal bone is essential to exposure of lesions of the facial nerve in the facial canal.

Doctor Lahey has expressed a preference for the spinal accessory nerve when a cranial nerve must be used to restore innervation to paralyzed muscles of the face. The choice of the nerve to be used has long been a subject of much controversy. As stated in my paper, we have used the hypoglossal because of its closer functional similarity to the facial. However there are cases in which the spinal accessory may be preferred. We have used the

spinal accessory in only one case, that of an old lady with facial paralysis following complete removal of an acoustic neuroma, who objected to any operation which would affect the nerve of her tongue. The point not being of great importance in her case, we were willing to use the spinal accessory.

From a careful study of patients, both before and after facio-hypoglossal anastomosis, I have not been impressed with any loss of function from sacrifice of the hypoglossal nerve. Voice records have been made of these patients before and after operation, showing no noticeable interference with speech. In complete lesions of the nerve proximal to its exit from the facial canal, function of the digastric, stylohyoid and buccinator is lost. That of the digastric and stylohyoid would be permanently lost regardless of which nerve is used in the anastomosis. It may be that some impairment of the hyoid stabilization has something to do with the speech and it is very probable, too, that the buccinator, like the frontalis, does not recover as completely after nerve graft or anastomosis as other muscle groups. Impairment of function of speech or deglutition, attributed to section of the hypoglossal on one side might be due in part at least to impairment of function in these three muscles and not to loss of the hypoglossal.

From my observation of section of the spinal accessory as a part of the surgical treatment of spasmodic torticollis I am inclined to believe that the loss of the hypoglossal is of less importance than that of the spinal accessory. In view of the fact that section of either of these nerves carries no considerable penalty, it would seem that the choice between the hypoglossal and the spinal accessory nerves in anastomosis should not be determined by the loss of function incident to section of the substituting nerve but should depend upon which nerve would bring about better facial movement.

THE FREQUENCY AND DIAGNOSIS OF HIATAL HERNIA¹

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AND

F HARRIMAN JONES, M D

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HIATAL HERNIA is the term used to designate a herniation of abdominal contents through the esophageal hiatus of the diaphragm. All herniae of the diaphragm, therefore, do not come under this heading, but of recent years the frequency with which the hiatal herniae have been recognized has been so great that the attention of the medical profession has been called to this condition in a startling way.

The first herniae of the diaphragm that were recognized were of the traumatic type. Ambroise Paré reported two cases of the traumatic type as early as 1610 and, in 1769, Moigagni wrote the first monograph on the subject. However, until recent years the hiatal type has not been well recognized. At the Mayo Clinic the first hiatal hernia was found at operation in 1908, but it was not until 1921 that the diagnosis was made by roentgenographic examination.

Moersch,⁴ in going over the records at the Mayo Clinic, found that, from 1932 to 1937, there were 267 cases in which there was a positive diagnosis of diaphragmatic hernia made at roentgenographic examination. Of this number, there were 246 of the hiatal type in contrast to 15 of the traumatic and six congenital herniae.

Harrington³ has gone back in the Mayo Clinic records to 1908, when the first case of hiatal hernia was recognized, as mentioned above, and found that from that time until 1926 the diagnosis of hiatal hernia was made just 17 times, but that from 1926 to 1938 the diagnosis was made 399 times. This is 23 times as many cases in the past 12 years as in the previous 18 years. Also, a marked increase in the roentgenologic diagnosis is startlingly brought out by the contrasting figures of one case in 1921 and 99 cases in 1937. During the period 1908-1938, a diagnosis of diaphragmatic hernia (all types) was made roentgenologically, or at operation, in 514 cases.

Others are also noting the same changes in the frequency of the diagnosis of this condition. At the Guthrie Clinic² there were five cases of hiatal hernia recognized and operated upon from June, 1927, to January, 1938. Since then (until November, 1939) there have been 14 cases found. These will be considered later in the paper.

Harrington believes that the hiatal hernia is no more frequent now than 20 years ago but that the apparent increase in the number of cases is due to the fact that both clinicians and radiologists are looking for the condition and

* Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 6, 7, 8, 1939.

both are coming to recognize the symptoms and findings of the disease. The diagnosis does not depend entirely on the radiologist but the clinician plays an important part by recognizing the symptoms and requesting the proper examination.

Hiatal herniae have been divided by Akerlund¹ into three types: (1) A congenitally short esophagus with partial or complete thoracic stomach, (2) a normal length esophagus not forming part of the hernia but with a para-esophageal hernia, and (3) a short esophagus forming part of the hernial contents. Moersch states that the first is usually due to embryologic retardation, but the possibility of such a picture occurring as a result of cicatrization of the esophagus cannot be dismissed. The other two types are of congenital origin in the same sense as inguinal herniae, and any factor that tends to increase intra-abdominal pressure may act as a contributory factor. Truesdale⁷ believes the cause is a relaxation of the muscle structure of the diaphragm superimposed on a congenital deficiency of tissue surrounding the lower end of the esophagus. Moersch, Ude and Rigler,⁸ and Akerlund all noted that the third or sliding type was more frequently found than the other two.

The first type needs little discussion. The esophagus may be so short that the stomach may lie almost entirely within the thorax. This is rare and is as a rule the only abdominal organ involved in the abnormal position. Usually the esophagus is not thus short and only a portion of the stomach is above the level of the diaphragm. There is often a narrowing at the diaphragmatic level and frequently spasm or even ulcer formation with bleeding occurs at this point. It is not reducible under ordinary conditions. Harrington says it is not a true hernia but an abnormality of development. The second and third types of this classification are the only ones which he lists as true herniae.

In the second type, which has a normal length esophagus, it is found that the lower end of the esophagus is attached to the hiatal ring and does not form a part of the hernial contents which are para-esophageal. It is usually reducible and frequently reduced when the patient is in the upright position—a factor that may lead to a missed diagnosis if the patient is not examined roentgenologically in the supine position.

The third type, or sliding hernia, in reality has a normal length esophagus but one which has become shortened as the cardiac end of the stomach has pushed through the hiatus. The esophagus does not remain attached to the hiatal ring. Ordinarily it is also easily reducible and in some patients remains reduced when in the upright position. Either of these latter two types may become irreducible if adhesions form in the mediastinum holding the stomach above the diaphragm.

Many of the hiatal herniae produce few or no symptoms, if there are symptoms, they are usually not clear-cut or specific of the condition. In general, the amount and type of abdominal viscera herniated is in direct proportion to the symptoms, involving only a portion of the cardiac end of the

stomach may produce more severe symptoms than a larger hernia involving the greater part of the stomach. Harrington also points out that a large majority of the patients will already have had an average of three erroneous diagnoses made before the true nature of the disease is discovered. He lists these in order of frequency as cholecystitis, cholelithiasis, gastric ulcer, duodenal ulcer, hyperacidity, secondary anemia, cardiac disease, carcinoma of the cardia, stricture of the esophagus, appendicitis and intestinal obstruction. Morton⁵ points out, however, that in older patients other diseases may actually be present and an accurate diagnosis becomes difficult.

One of the most constant and most frequent of symptoms is pain situated under the lower end of the sternum. This pain frequently radiates through to the back, is usually mild in onset, and comes on during or shortly after eating. Frequently, the patient will notice that liquids are easily taken but that solid food, unless very well masticated, will cause discomfort. Again, they will also note that after a very large meal they are more likely to have distress than if a small meal is taken and overeating is not indulged in. When present, this pain often leads to confusion with peptic ulcer because there may be relief from food, milk or soda. If the pain is more severe and associated with vomiting, one might easily confuse the diagnosis with gallbladder disease. Other symptoms are vomiting, hemorrhage, belching, weakness and anemia. Occasionally in the large herniae there is pulmonary or cardiac embarrassment with symptoms of dyspnea and palpitation. Spasm of the diaphragm may cause phrenic pain in the left shoulder or even simulate angina pectoris. Moersch points out that the symptoms frequently are intensified or aggravated by the recumbent position.

Bleeding comes from the mucous membrane of the stomach following erosion or ulceration and, when present, indicates an incarceration at the hiatal ring. Subacute perforation was demonstrated at operation in one of the cases reported by Guthrie and Brown². Because of the heavy musculature of the stomach wall the stomach does not become strangulated. Harrington says that strangulation is not possible because of the "powerful musculature and rich blood supply of the gastric wall."

The definite diagnosis of hiatal herniae rests upon roentgenographic recognition. The hiatal hernia can be most easily seen with the patient in the recumbent position. Only in those where it does not reduce easily in the upright position or in those in which it is fixed by adhesions in the thorax can it be recognized while the patient is standing. In brief, the roentgenologic examination is carried out as follows. While standing in front of the fluoroscope the patient is asked to take one swallow of the barium mixture. This is watched as it passes down the esophagus and into the stomach. Often, as the barium passes the cardia there is a suspicion of a hiatal hernia. The routine examination of stomach and duodenum is then carried out as the patient finishes drinking the barium mixture. The table is then tilted so that the patient is in the prone position. Further examination of esophagus, stomach and duodenum are carried out. The patient is also turned face down so that

the barium filled portions of the gastro-intestinal tract may be studied from all angles. Roentgenograms are taken with the patient in the supine position. The head is turned to one side and a mouthful of barium is sucked up through a glass tube and swallowed. This barium is watched while it passes through the esophagus as the patient swallows against gravity. The exposure is made just after this part of the procedure.

In those having a congenitally short esophagus the hernia cannot be reduced and, therefore, is apparent in both upright and recumbent positions. The upper portion of the stomach is usually pointed and the esophagus empties into this upper or peaked portion. In the true hiatal herniae (the para-esophageal and sliding types) the contour of the herniated portion of the stomach is rounded. The distal end of the esophagus enters the stomach in its normal position. In the para-esophageal variety the lower end of the esophagus is fixed to the hiatal ring but in the sliding type it may be seen to change its relation in the thoracic cavity. It is important in this sliding type to determine whether the esophagus is of normal length or not.

Moersch stresses the value of esophagoscopy in the study of this condition. The findings in the patients with a congenitally short esophagus are a narrowing of the esophagogastric junction with a dilated portion below this point showing folds of gastric mucosa. There is no evidence of the normal diaphragmatic hiatus. The narrowing may be fusiform and from 1 to 7 cm in length or may be a membrane which partially obstructs the lumen. There may be ulceration at this point which often simulates that of carcinoma.

The sliding type hernia may closely resemble the congenitally short esophagus. Here, however, the esophagus is more redundant and the point of narrowing is less pronounced and shorter. In some cases it may be advisable to examine the patient fluoroscopically with the esophagoscope in place, in order to determine the exact relation of the esophagogastric junction.

Esophagoscopy is especially indicated in the bleeding cases, in order to determine the extent of the erosion or ulceration and to rule out the possibility of another lesion causing the bleeding. Harrington feels that it should be carried out in every case of hiatal hernia in which operation is to be undertaken. Carcinoma of the cardia has been found in connection with hiatal hernia, and using esophagoscopy in making the positive diagnosis tends to minimize unforeseen therapeutic problems.

Not all hiatal herniae should be subjected to surgery, although in the larger herniae, and those producing severe symptoms, a surgical procedure is the only means to relieve the patient. An absence of symptoms or very mild symptoms are contraindications to surgery but it is important to have a record of the condition so that any increase in symptoms will not be judged to have a surgical or cardiac basis.

Root and Pritchett⁶ believe that, in the medical management of these patients, they should be instructed to eat frequent, small meals and remain erect for some time after eating. They should not eat just before retiring at night. Moersch feels that the procedure of choice in patients with a con-

genitally short esophagus is to dilate the narrowing at the esophagogastric junction. He does point out, however, that, if there is no definite stenosis and no ulceration of the mucous membrane, it may not be a true congenitally short esophagus although the roentgenologic and esophagoscopic examinations might point to this. Harrington has operated upon such patients and found that the stomach could be reduced and that the esophagus was not actually shorter than normal. In the very obese patient a simple reduction in weight will often relieve the symptoms.

Harrington, who has had the largest experience in the treatment of hiatal herniae, divides them into three groups from the standpoint of treatment. The first includes those without or with only mild symptoms who do not need any treatment. In the second are those with moderate symptoms who require only conservative measurements, as regulation of diet and reduction of weight. In the third group are those with severe symptoms or those who have not found relief from the conservative means, these require an operative procedure. He also places in this operative group those patients with herniae larger than 5 cm in diameter and all those where the colon may be involved in the hernia.

Interruption of the phrenic nerve should be effected before a radical operative procedure and is a necessity if dealing with the congenitally short esophagus and thoracic stomach. In some cases, where a radical operation is contraindicated, section of the phrenic nerve may be employed as a palliative measure. When used with direct attack on the hernia, temporary interruption is preferred unless there is some indication to make it permanent. As a palliative means, it is employed to prevent spasm of the diaphragm and thus cut down the severe attacks with danger of incarceration of the stomach and to give the medical treatment a chance to heal ulcers of the gastric mucosa. It usually does not completely relieve the symptoms but the patients get along well if they are careful with their diet.

Operative Technique—The abdominal approach is most frequently employed in repairing the hiatal hernia. By cutting the suspensory ligament to the left lobe of the liver it can be retracted to the right, exposing the left hypochondrium. The stomach should be explored for any pathologic lesion which may be associated with the hernia. Wide exposure is necessary and after being reduced from its thoracic position the stomach must be retracted strongly downward.

Harrington stresses the importance of removing the hernial sac. It is well to point out that the hernial sac in the hiatal hernia is in the posterior mediastinum and not in the pleural cavity. We pass a stomach tube after the sutures are placed to make sure the lumen of the esophagus is not constricted. The suture nearest the esophagus should include a small bite of the outer layers of the wall of this organ to insure its being fixed in normal position and to keep it from tending to draw again into the thorax. Before closing the abdomen, other organs especially the gallbladder, should be explored.

Postoperatively, any signs of shock must be immediately combated. An

oxygen tent may be employed to advantage but we have not found many patients requiring this treatment. However, our series of operated cases is small. Ventilation of the lungs with carbon dioxide and oxygen twice a day for three days aids greatly in preventing postoperative pulmonary complications. Liquids may be started as tolerated by the patient, followed by a modified soft diet on the third or fourth postoperative day. The care of the wound is that of any other abdominal incision.

Ten of the 14 cases seen here since January, 1938, have been females. Nine of the 14 have been treated by conservative means. One was treated conservatively plus a dilatation of the esophagus. On one, a phrenectomy was the only operative procedure directly associated with the hiatal hernia. On three, phrenectomy was performed and the enlarged hiatal opening was repaired. A brief summary of these 14 cases is appended.

ABBREVIATED REPORTS OF 14 CASES OF HIATAL HERNIAE

Case 1—Female, age 62, was examined in May, 1938.

History—Substernal pressure, six weeks, food lodged in throat, belching of gas, pain to right of spine below costal margin, intermittent, five years. Physical examination was essentially normal. Roentgenologic examination demonstrated a small hiatal hernia. Treatment: None.

Case 2—Female, age 58, was examined May 12, 1939.

History—Indigestion for several years, severe anemia, two years previously, roentgenologic studies were negative at that time, severe anemia just before admission. Operation: appendicitis, duodenum explored. Physical examination was essentially normal. Roentgenologic examination demonstrated a large hiatal hernia, ulceration at diaphragmatic ring. Easily reduced. Treatment: Conservative, back rest, Sippy diet, etc.

Case 3—Female, age 63, was admitted December 30, 1938.

History—Cellulitis of legs, "stomach trouble" for some time, difficulty in swallowing, burning in epigastrium, attacks of nausea and vomiting. Physical examination elicited soreness in epigastrium, otherwise normal. Roentgenologic examination demonstrated a hiatal hernia, 4 cm in diameter. Treatment: Conservative. Symptoms persist but are not severe.

Case 4—Female, age 38, was admitted June 5, 1939.

History—Mild choking sensation, constriction around neck for one year, heartburn, palpitation on exertion. Physical examination was essentially normal. Roentgenologic examination demonstrated a large hiatal hernia, approximately 7 cm in diameter. Treatment: Conservative, antispasmodic. Improved.

Case 5—Male, age 80, was examined June 21, 1938.

History—Abdominal pain followed by gastric hemorrhage and unconsciousness, six months previously, had been taking a nonresidue diet and alkaline powders since that time, had no complaints when examined here. Physical examination was essentially normal. Roentgenologic examination demonstrated a small hiatal hernia. No lesion of stomach or bulb. Treatment: Conservative, antispasmodic.

Case 6—Male, age 40, was admitted March 13, 1938.

History—Hematemesis and tarry stools, 36 hours, no stomach complaints previously, no distress. Physical examination elicited slight epigastric tenderness, secondary anemia. Roentgenologic examination demonstrated a hiatal hernia. Gastric mucosa 2 cm above diaphragm. Treatment: Conservative, restricted diet, alkaline powders. Follow-Up, November 17, 1939. No distress whatever.

Case 7—Female, age 58, was admitted August 16, 1939.

History—Difficulty in swallowing for two years, liquids taken but solid food caused trouble, vomiting with above for a few weeks, nervous and had strenuous work. Physical examination was essentially normal. Roentgenologic examination demonstrated a small hiatal hernia, some pylorospasm. Treatment: Dilatation of esophagus, four times, August 22, 23, 31, and September 1, 1939. Antispasmodics. Follow-Up: Condition but little improved. Plan to section phrenic nerve.

Case 8—Female, age 64, was admitted August 21, 1939.

History—Severe digestive disturbance with pain and vomiting, seven months, occasionally vomited blood and had tarry stools, had lost 100 pounds in weight. Physical examination: Weight 213 pounds, mild hypertensive heart disease, postoperative ventral hernia, tenderness in epigastrium. Roentgenologic examination demonstrated a hiatal hernia, lesion on lesser curvature in thoracic portion of stomach. Esophagoscopy: Showed thoracic portion of stomach, lesion not seen. Treatment: Phrenectomy, September 6, 1939. (Ventral hernia November 1, 1939.) Good result. Follow-Up, November 22, 1939. No distress whatever.

Case 9—Female, age 43, was first admitted in 1923.

History—Choking, food distress, vomiting blood. Operative duodenal ulcer in 1923 (gastro-enterostomy and cholecystectomy). 1928—Disconnection of gastro-enterostomy. 1929—Symptoms returned. Conservative treatment. 1939—Belching gas, epigastric pain 15 to 20 minutes after eating. Physical examination was essentially normal. Roentgenologic examination demonstrated a large hiatal hernia. Treatment: Phrenectomy, February 14, 1939, diaphragm closed with silk. Follow-Up: Still has small hiatal hernia. No epigastric distress. November 21, 1939. Some return of symptoms. Choking sensation, not as severe as previously.

Case 10—Female, age 57, was examined August 27, 1939.

History—Vomiting after meals since childhood. Treated for stomach ulcer, epigastric distress. Physical examination was essentially normal. Roentgenologic examination demonstrated a hiatal hernia, 5 cm in diameter. Treatment: Phrenectomy, September 5, 1939. Hernia closed with silk.

Case 11—Female, age 59, was examined August 28, 1939.

History—Nausea, pain and fulness in epigastrium for two years. Diagnosed elsewhere as malignant tumor of cardia, in 1937. Physical examination elicited tenderness throughout abdomen, achlorhydria. Roentgenologic examination demonstrated a hiatal hernia, filling defect of the cardiac end of stomach. Treatment: Phrenectomy, September 19, 1939. Hernia closed with silk. No tumor found. Cholecystectomy and choledochostomy.

Case 12—Male, age 66, was examined October 12, 1939.

History—Stomach trouble for years, diagnosed (here) coronary, in 1933, gastric hemorrhage, duodenal ulcer in 1936 and 1937. Physical examination was essentially normal. Roentgenologic examination demonstrated a hiatal hernia. Treatment: Conservative. Nothing done.

Case 13—Male, age 63, was examined September 29, 1939.

History—Stomach trouble for two months (one attack four years before, roentgenograms negative), careful of amount of food—not type of food, slight abdominal distress, occasional nausea and vomiting. Physical examination elicited slight epigastric distress. Roentgenologic examination demonstrated a hiatal hernia. Treatment: Conservative.

Case 14—Female, age 67, was examined in September, 1939.

History—Cholecystectomy in 1922. Attacks of gas, occasional nausea and vomiting, had car injury two months before study—symptoms of congestive heart failure. Physical examination was essentially normal except for very mild congestive heart failure, achlorhydria. Roentgenologic examination: (1) Heart 10.5 undersize, small atelectasis, (2) multiple diverticulosis, (3) hiatal hernia. Treatment: Conservative.

The incidence of hiatal hernia is still higher than one would expect. Many more cases are being recognized each year than previously, and if the condition is kept in mind when examining the patient with atypical gallbladder and stomach complaints, a larger number of these will be discovered. Low substernal distress, inconstant and mild in character, noted especially after large meals, is an important symptom. The clinician aids in the diagnosis by becoming suspicious of the presence of hiatal hernia and requesting appropriate examinations.

It is necessary for the roentgenologist, especially, to be on the alert for this disease and to always examine the esophagus and stomach with the patient in the recumbent as well as in the upright position.

It is well to have the knowledge that the condition exists so that in the event of an increase in symptoms the patient will not undergo a needless operation for a suspected abdominal lesion or be placed upon a cardiac regimen.

Not all of the lesions are surgical conditions and conservatism can be carried out in many cases after the diagnosis is made.

REFERENCES

- ¹ Akerlund, A. *Acta Radiol*, 6, 3, 1926
- ² Guthrie, Donald, and Brown, M. J. *Guthrie Clinic Bull*, 7, 108, 1938
- ³ Harrington, Stuart W. *Jour Thor Surg*, 8, 127, 1938
Idem *California and West Med*, 50, 399, 1939
- ⁴ Moersch, H. J. *Ann Otol, Rhinol and Laryngol*, 47, 754, 1938
- ⁵ Morton, J. J. *Surg, Gynec and Obstet*, 68, 257, 1939
- ⁶ Root, J. C., and Pritchett, C. P. *Cleveland Clin Quart*, 5, 203, 1938
- ⁷ Truesdale, P. E. *Southern Surg*, 8, 1, 1939
- ⁸ Ude, W. H., and Rigler, L. G. *Minnesota Med*, 12, 751, 1929

UMBILICAL AND MIDLINE VENTRAL HERNIAE *

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THE STORY of hernia parallels closely the history of surgery. In no other branch of surgery has progress been more gradual and less dramatic. Always an exterior problem, hernia has been of interest to the earliest medical authors. Its records, instead of showing how much the ancients knew, demonstrate how little essential knowledge they had concerning a problem regarded as being among the simpler procedures of modern surgery. It also demonstrates how ineffectual, and even hopeless, were the older efforts at treatment. We still have much to be desired in the treatment of herniae and the prospects for improvement in the future remain great. Undoubtedly many more improvements, some even as important as those of Halsted^{1, 2} and Bassini,³ will be made. Advances in the surgery of hernia, which will promise more certain assurance of permanent successes, are needed. Even more often than we generally appreciate, the cure is only temporary.

Besides infection, which was one of the greatest deterrents to operation, the ancients did not know how to repair the hernial defect. Their procedures were most ineffectual. Galen⁴ cut across the spermatic vessels and sac, Celsus⁵ removed the testicle and sac. The description of the operation for inguinal hernia given by Paulus Aegineta,⁶ who lived not later than the sixth century, states: "After placing the patient in the recumbent position and getting the skin in the groin stretched by an assistant, we make a transverse incision. Then we stretch out the incision to such a degree as to afford room for the testicle to pass through. An index finger is introduced to the back part of the scrotum to bring the testicle with the tunica vaginalis into the incision. We ascertain whether a fold of intestine be caught in the tunica vaginalis. If so, we must press it down into the belly. Then we take a large-size needle containing a double thread and pass it through the middle at the extremity of the peritoneum close to the incision. We bind the peritoneum securely. Then making an incision at the lower end of the scrotum to save a discharge, we introduce an oblong pledget and apply embrocations of oil." This was fairly characteristic of all operations described for hernia before those of Bassini and Halsted. The older operations consisted of simply tying off the sac without repairing the defect in the abdominal wall. Some ancient physicians burned the area of the external ring down through the fat layer with an actual or potential cautery, expecting the resulting scar tissue to hold back the hernia.

Petit,⁷ who lived from 1674 to 1750, was one of the first to make any at-

* Read before the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

tempt to sew fascia over the defect. This he did by suturing the internal pillar of the external oblique to the external pillar, in an attempt to obliterate the external ring of the inguinal canal. He employed a gold suture, which may have been the origin of the term "crown-stitch." No more efficient operation was devised to repair a hernia until about 1889, when Halsted and Bassini, almost simultaneously, described their operative procedures.

Before Bassini and Halsted, even able surgeons with large practices usually regarded operation for hernia as a procedure attended with such dangers, and so little promise of success, that they recommended operation only for complicated herniae such as strangulated ones. Trusses were advocated even for irreducible herniae by Sir Astley Cooper⁸ (1768-1841), a cup-shaped support being employed.

Before the sixteenth century, patients with strangulated herniae were abandoned to their fate. The physician's efforts were directed to relief of the ileus and distention, but not by release of the strangulation. No operation was performed, and measures for relief consisted in attempts at reduction by taxis and other palliative measures. During the sixteenth century, the operation of cutting the constricting ring for strangulated hernia made its appearance. According to Malgaigne,⁹ Maupas, in 1551, was the first to operate for strangulated hernia. The operation consisted of a free incision into the abdomen in the region of the pubis and the reduction of a scrotal hernia. The hernia recurred. This was a great advance, but shortly thereafter Pierre Fianco,¹⁰ in 1561, described cutting the ring without incising the sac for release of strangulation. This was a further improvement because it obviated going into the peritoneal cavity and reduced, in those days, the dangers of peritonitis. However, Heister¹¹ (1683-1758), an outstanding German surgeon of his day, advocated attempts to reduce irreducible or strangulated hernia by taxis. If this failed, he advised clysters, even of tobacco smoke, by the use of which he said he often had surprising success. If the hernia remained unreduced for 24 hours, he advised operation, which consisted in cutting the ring. If, after opening the sac, the omentum was found to be gangrenous, it was cut off, but if intestine was found to be gangrenous the wound was simply dressed with lint. Further advances in the treatment of strangulated hernia concerned surgery for the gangrenous intestine. Trusses continued to be the method of choice for the treatment of all herniae except strangulated ones, even to the end of the nineteenth century. Scarpa¹² (1747-1832) advised the use of a truss even after operation, because he said the hernial sac cannot be closed up to the abdomen and recurrence otherwise resulted. Macready,¹³ in a monograph in 1893, still advised trusses except where operation was absolutely necessary.

The measures employed for the radical cure of umbilical hernia were just as imperfect as the older measures for inguinal hernia. Celsus⁵ recommended pressure on umbilical herniae between two rulers or ligation of the entire hernia, permitting the umbilicus and sac to slough out and heal by scarring below the ligature. Paulus Aegineta ligated the sac permitting the distal part

to slough off. A method with a similar principle has been advocated even in recent times¹⁴

Storer,¹⁵ in 1867, was among the first to suture the fascia together to cure umbilical hernia. With an elliptical incision, he excised the umbilicus and sac. He worked from below upward, putting in metallic sutures as fast as he removed the sac. These sutures included all tissues of the abdominal wall. Buried sutures generally were not employed at that time. Storer operated upon a patient having very doubtful indications for surgery. Definite contraindications were present. His patient, a female, age 41, had had repeated attacks of jaundice and hepatic pain. He performed an exploratory operation through a lower midline incision. The liver was atrophic and the gallbladder distended. He closed the abdomen and the patient recovered. Shortly thereafter, the patient began to have marked distention of the umbilicus because of accumulation of ascitic fluid. He was forced to tap her more often than otherwise fearing, he said, a rupture of the umbilicus. Because of this, he chose to repair the umbilical hernia. The patient died, and on reporting the case at a meeting, he was severely criticized by a number of his contemporaries for performing a useless operation. He, too courageously, published his critics' views saying he would leave to posterity the judgment of the merits of his operation. However, present judgment cannot altogether condone the selection he made in subjecting what appears to be a hopelessly sick patient to a procedure which promised too little even for the cure of the defect for which it was intended.

Clinical Material Considered—During the two-year period, 1937 and 1938, 112,686 patients were admitted to Charity Hospital, New Orleans. Of this number, 170 patients had herniae of the umbilicus or midline of the abdomen. Umbilical herniae accounted for 136 of these, linea alba herniae accounted for only 10, and midline incisional herniae were present in the remaining 24 patients. Fifty-seven of the patients with umbilical or midline ventral herniae were operated upon for the hernia. Forty-one of the herniae were of the primary umbilical type, 12 of the series were incisional herniae, four of which were umbilical, one epigastric, and seven lower midline herniae. Four of the cases were primary epigastric herniae.

Race and sex are important factors in the development of these herniae. The colored race seems to have a predisposition to umbilical hernia. Of the 136 cases of umbilical herniae, 97 (62 per cent) were in the colored race and 39 (28 per cent) were in the white race. During the same period, 53 per cent of the total admissions were white and 47 per cent were Negroes. Thirty of the 41 patients with primary umbilical herniae subjected to surgery were women. Twenty-two of these women were Negroes and eight of the 11 males were Negroes. The cause of higher incidence in the Negro may be explained on less meticulous care during the postnatal period, and possibly to a greater prevalence of rickets in that race. Undoubtedly, however, there is a racial predisposition to the defect in addition to the factors mentioned. The underlying causes are probably absence of the umbilical fascia in a higher percentage of Negroes than in the Caucasian race. Gorelow¹⁶ found the umbilical fascia

deficient in 40 per cent of 300 bodies studied. So far as can be determined, no such study has been made in the colored race. This deficiency of fascia permits the development of umbilical hernia much more readily when other etiologic factors appear.

Two common operative causes of umbilical hernia are (1) obesity, and (2) pregnancy. The influence of obesity in the development of umbilical and midline ventral herniae of surgical significance, is definitely shown in this series of 41 cases. Seventeen of the patients with umbilical herniae were described as obese or very obese. Six of the 12 patients with incisional herniae were obese. Indeed, so often do umbilical herniae become serious problems in stout women, that any tendency to obesity should be considered an indication for surgery for an otherwise inconsequential hernia.

Though many of these herniae are lifelong in duration, it is surprising how many of the patients date the appearance of the hernia to a recent time. Many of these patients have small herniae, which are recognized only when another factor makes them enlarge. One-fourth of the patients gave the duration of the hernia as under two years.

Primary hernia of the linea alba is not common. There were only 10 recorded diagnoses of this condition among these 112,686 admissions. Hernia of the linea alba is usually located above the umbilicus. Primary herniae of the linea alba below the umbilicus are extremely rare. Linea alba herniae are usually small. They frequently begin by protrusion only of preperitoneal fat through a small opening, subsequently a projection of peritoneum follows as the ring of the hernia enlarges. Omentum enters the sac and may be followed by intestine. Preperitoneal fat is frequently the only hernial protrusion in epigastric hernia. In four primary epigastric herniae it was found twice. In the other instances the contents of the hernia were not mentioned. In 41 operated umbilical herniae, preperitoneal fat alone was found in the hernia in seven instances. Only one of these was strangulated. The frequency of preperitoneal fat forming the herniation in epigastric herniae is explained by the abundance of preperitoneal fat in this vicinity around the round ligament of the liver. The idea that epigastric herniae usually cause gastric symptoms by pull on omental contents is fallacious. Some further cause for the gastric symptoms must be diligently searched for before such a conclusion is arrived at. Even then, if the gastric symptoms are attributable to the hernia, the mechanism is probably reflex and not mechanical.

The ages of patients operated upon for umbilical hernia in this series varied from 3 to 68 years. The oldest patient had a strangulated hernia. Most umbilical herniae, regarded as surgical, are in patients in the middle decades of life. Thirty of 41 umbilical herniae were in the third, fourth, and fifth decades.

The type of operative procedures employed in this group of cases was varied. These 57 cases of umbilical and midline ventral herniae were repaired by 33 surgeons. The types of operative closure chosen were The Mayo in 21, longitudinal approximation in 12, longitudinal overlapping in two, and split-

ting the rectus and separate approximation of anterior and posterior sheaths in three. In this group the umbilicus was excised in 25 instances.

In the 12 cases of incisional hernia, the records stated that a Mayo type of closure was performed, in five, longitudinal approximation of the linea alba was effected. In the remaining two cases, a longitudinal (side-to-side) overlapping closure was made. In the four linea alba repairs, the Mayo type of closure was effected in two cases, transverse approximation in one, and longitudinal overlapping (side-to-side) in one.

Infections developed postoperatively in 11 of 57 cases. In the repair of 45 of these, catgut was employed and infections developed in nine instances (20 per cent). In one of these there was an evisceration, in one there was a very superficial infection (skin suture). In the repair of 10 cases, silk was employed—and infection developed in one (10 per cent). In two cases, the type of suture material employed was not noted. One of these developed an infection.

Seventeen of the herniae were irreducible, and 11 were strangulated—necessitating emergency operations. Two patients died following operation for strangulated herniae. The mortality, therefore, in the entire group was 3.5 per cent, and in the group of strangulated herniae, 18 per cent.

A female, age 45, was admitted with an umbilical hernia, which was said to have been irreducible for three days. It was strangulated. At operation omentum was found in the sac. A Mayo type of closure was performed. The patient died on the second postoperative day and at necropsy a gangrenous loop of bowel was discovered.

A female, age 50, was admitted with an umbilical hernia strangulated for two days. At operation, a hernia of the Richter type was found. There was no evidence of gangrene of the bowel. The anesthetic employed was ethylene and ether. The closure was of the Mayo type. The patient died six hours after operation. Necropsy showed no definite cause of death—it being explained as a "postoperative state."

Information concerning the final results (over one year postoperative), was obtained by letter from 28 patients. Four of these admitted recurrences, and these recurrences were among 22 cases with umbilical herniae. The recurrence rate, therefore, by letter, for umbilical hernia was 18.2 per cent. Fifteen of these patients were examined, and in this group, all of whom answered by letter previously, two admitted recurrences, by letter, but examination revealed four recurrences. Of the 15 patients examined for recurrences 11 had been operated upon for umbilical herniae. In these 11 patients, four had recurrences, thus the true rate for recurrence of umbilical hernia in examined cases was 36.36 per cent. The four patients who had recurrences were all obese. They weighed 210, 195, 170 and 286 pounds, respectively. On the other hand, two patients who did not show recurrences on examination weighed 206 and 207 pounds, respectively. It is obvious that though obesity is a potent factor in the incidence of recurrence, its presence does not always preclude a permanently good result.

Types of Repair —In a discussion of present methods of operating for umbilical or linea alba herniae, Storer's article, 1867, deserves comment because it was, apparently, the first effort to do more than simply tie off the sac. Whether he realized the importance of getting the edges of the fascia together is not clear, since he sutured tissues *en masse*. This, however, antedated, by a number of years, the fundamental procedures advocated by Bassini and Halsted for cure of inguinal hernia. Apparently, surgeons quite generally, at the end of the last century, appreciated the necessity of closing the abdominal wall and fascia, and not merely tying off the sac. Lucas-Championniere,¹⁷ in 1895, after realizing the frequency of recurrences, attempted to strengthen the wound in umbilical hernioplasty by overlapping the linea alba and sheath of the rectus from side-to-side. Mayo,¹⁸ in 1899, described his operation of overlapping the fascia from above down. This has proved one of the most reliable operations for certain types of umbilical herniae, and, in follow-up studies of cases, usually proves superior to other methods by showing the minimum number of recurrences.

Since then, various types of procedures have been described, and redescribed, for the radical cure of umbilical herniae (Fig. 1 A and B). McGlannan,¹⁹ and Stone²⁰ have both described operations for umbilical hernia at meetings of this Society. Other presentations before the Southern Surgical Association on ventral hernia, were given by Wathen,²¹ Johnson,²² Werder,²³ Bartlett,²⁴ and McGlannan.²⁵ The methods of hernioplasty may be included in the following types:

- Longitudinal approximation of fascia
- Transverse approximation of fascia
- Longitudinal or transverse overlapping
- Relaxing incisions, arcuate above and below or laterally, to permit further mobilization of the fascia edge
- Splitting the rectus sheath and exposure of the muscle
- Mobilization of each rectus muscle, usually through a transverse incision in the anterior rectus sheath, in order to permit suturing the muscle edges under less tension in the midline (Pfannenstiel,²⁶ Graser²⁷)
- Fascial sutures to approximate the edge of the fascia
- Fascial flaps, or sheets, to repair the defect
- Purse-string suture of the umbilical ring

Next in importance to the anatomic plan of closure, is the material employed for closure. The controversy now current concerning the comparative value of silk and catgut probably regards one of the most important features of the surgical repair of hernia. Practically all studies dealing with this are favorable to silk, which has a lower incidence of infection and recurrence than after the employment of catgut. Undoubtedly, silk in an infected wound may delay complete healing of the wound for a longer period than if infection occurs in the wound sewed with catgut. On the other hand, silk may offer more security in that fewer infections occur when it is employed, and recurrences are less

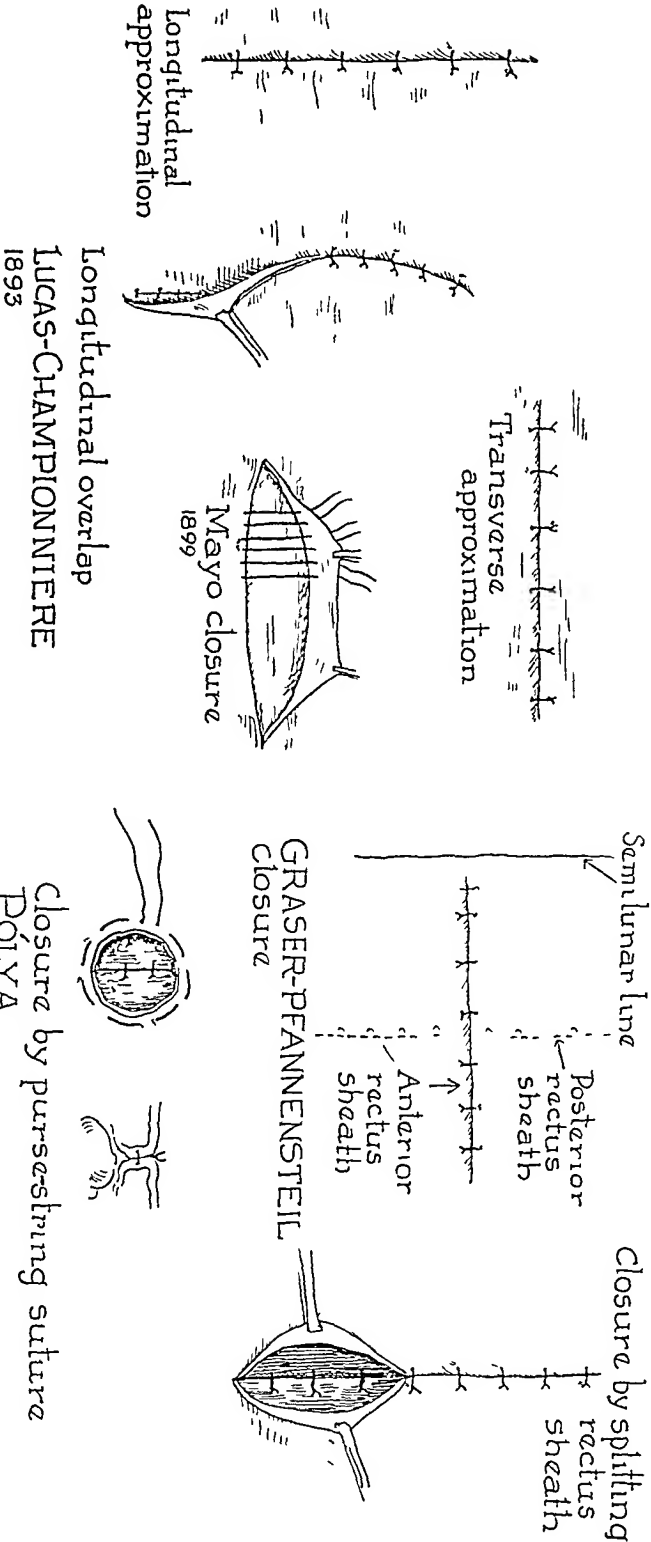


Fig. 1—Types of closure for midline ventral and umbilical hernia. The type of operation employed depends on the size and shape of the hernial defect. Longitudinal approximation or overlapping of the fasciæ should seldom be employed. Transverse approximation is not as secure as the Mayo type of closure. The Graser Pfannenstiel operation consists of mobilizing the muscles by freeing them from their sheaths and approximating them in the midline. It is an extensive procedure and is seldom indicated. Closure, by splitting the rectus sheath and separate approximation of the posterior and anterior layers, is indications for hernial openings long in the sagittal plane. Purse string closure is effective for small round defects.

frequent Meleney,²⁸ reporting infections occurring in a series of cases operated upon at the Presbyterian Hospital, New York, found that over a nine-year period, infections developed in 8 per cent of the wounds sewed with catgut, and in 3 per cent of wounds sewed with silk. The same author reported that, in 176 inguinal herniae sewed with catgut, the incidence of infection was 5.1 per cent, while following 303 operations for inguinal hernia in which silk was employed, the incidence of infection was 2.3 per cent.

In repairing the 41 cases of primary umbilical hernia reported herewith, catgut was employed in 32, with five infections (15.6 per cent), and silk was employed in 10 with one infection (10 per cent). Series of cases with follow-up adequate to show final results are few. Many factors are involved in recurrences, including the size of the hernia, age and weight of the patient, the incidence of infection, the suture material employed, and, not the least, accurate approximation of good tissue without undue tension at operation. Some of these factors may be favorably influenced, others are unchangeable. In estimating results it is difficult to determine the influence of one factor alone. Because of this, it is not easy to settle, unquestionably, the important question of the advantages of one suture material over another. Simmons²⁹ reported the results of operations for umbilical hernia performed at the Massachusetts General Hospital. There were 15 small congenital umbilical herniae, 43 large umbilical herniae, and 12 strangulated herniae. Of 10 followed cases of small umbilical herniae, none recurred. Of 39 followed cases in which large herniae, or strangulated herniae, had been repaired, the herniae recurred in 10 (22.2 per cent). Where the Mayo operation had been performed, the hernia recurred in 10 per cent. In 14 cases, where the ring was closed by longitudinal approximation, the rate of recurrence was 42.8 per cent.

Statistics which better show the influence of suture material are found in the study of Longacre,³⁰ and Parsons,³¹ from the Presbyterian Hospital, New York. In 925 hernioplasties of all types, in 752 patients, Longacre found the incidence of wound infection in wounds repaired with silk to be 2.55 per cent, while infection occurred in 15 per cent of wounds repaired with catgut. In the entire series, silk was employed in 496 hernial repairs and catgut in 270. The incidence of recurrence of the hernia was as follows: Silk group, 3.4 per cent; catgut group, 12.5 per cent.

It was hoped that the use of autogenous fascia as a living suture, as proposed by Gallie and LeMesurier,³² would improve the outlook for more permanent results in operations for hernia. Free fascial sheets, with edges cut into many tails, and employed as sutures, were utilized by Gallie³³ for repair of large defects. Careful postoperative studies of repairs with fascia are few. It is true that usually only the more difficult hernia operations are repaired with fascia. Surprising, if discouraging, are the results reported by Buddick, Gillespie and Higginbotham.³⁴ In 1,153 hernia repairs with fascia the incidence of infection for autogenous fascia, homologous fascia and ox fascia was 7.9, 12.8 and 12.1 per cent, respectively. In 975 followed cases, of all types of hernia, there were 284, or 29.1 per cent recurrences after the use of fascia. These authors do not regard fascia as a method of choice for more

difficult hernia repairs. Since adopting the silk technic they employ fascia only in the form of a pedicle flap, as described by Wangenstein,¹⁷ for large ventral herniae. In my experience, silk is the material of choice in the repair of herniae.

Preoperative preparation is a very essential part of the treatment of certain umbilical herniae. Large herniae, which have remained irreducible for any length of time, are said to have lost their right of domicile. There exists an unfavorable disproportion between the size of the abdominal cavity and the contents. Especially if the patient is obese and the hernia large, reduction and closure without tension may be very difficult. Even after replacement is accomplished and closure of the abdomen effected, difficulty may be encountered subsequently with dyspnea and cyanosis and sensation of oppression experienced by the patient. This phenomenon is more prone to occur after repair of upper abdominal herniae than after closure of an equally large hernia in the lower abdomen. It is due not only to an increase in intra-abdominal pressure and interference with the descent of the diaphragm, but also in upper abdominal herniae, to a restriction in the flare of the costal borders, and thus a limitation of that part of expansion afforded by the increase in intrathoracic space. Patients with large ventral herniae should be subjected to a preoperative period of preparation, lasting from a few days to a month. In this preoperative period, not only should attempts be made to improve the general condition of the patient, but specific attention should be directed to improving the circulatory system and kidney function. If there is any question concerning the heart, special studies should be made and cardiac stimulants prescribed. At the same time, efforts to reduce the weight of the patient should be instituted.

After the hernia is reduced, a binder should be placed on the patient to maintain reduction at all times. Elastic supports made of material, such as "LasteX," result in increasing intra-abdominal pressure. If the patient cannot stand pressure at first, short periods and relatively light pressure should be used. The duration and degree of pressure is gradually increased. The object is to subject the patients to increasing abdominal pressures so that they may develop a tolerance to any additional pressure which may result from the replacement of the hernia and closure of the defect at the time of operation. Periods of preoperative preparation should last from a few days to several weeks. These essentials were, long ago, appreciated and advocated by Graser,²⁷ Hahn,³⁶ McGlannan,¹⁹ and others. If the hernia is large and remains irreducible, Hahn has advocated performing the operation in two stages. At the first stage, the sac is dissected free and opened and adhesions are separated, reduction is accomplished. If there is difficulty making a closure of the fascia at this time because of tension, only the skin is closed and at a subsequent date a secondary operation is performed to obliterate the hernial defect. In the interval between the two operations, the patient undergoes a period of preparation in which increasing extra-abdominal pressure by binders is employed.

A two-stage procedure allows the partial correction of factors which prevent closure without tension. In the interval between operations, the patient

can be accustomed to increased intra-abdominal pressures by binders and the relative disproportion between contents and abdominal cavity can be corrected partially by weight reduction. The recti muscles can be accustomed to their normal anatomic relation of juxtaposition by keeping the hernia reduced and keeping the muscles approximated by a binder. A two-stage procedure is more often indicated for large herniae, particularly long oval hernial openings, with the long diameter in the vertical axis of the body. Here, one would be forced to make some sort of closure in the line of the long axis, that is, a type of longitudinal approximation in the vertical plane.

Choice of the Type of Operation for an Umbilical or Midline Ventral Hernia—The recti muscles arise from the xiphoid and from the costal car-

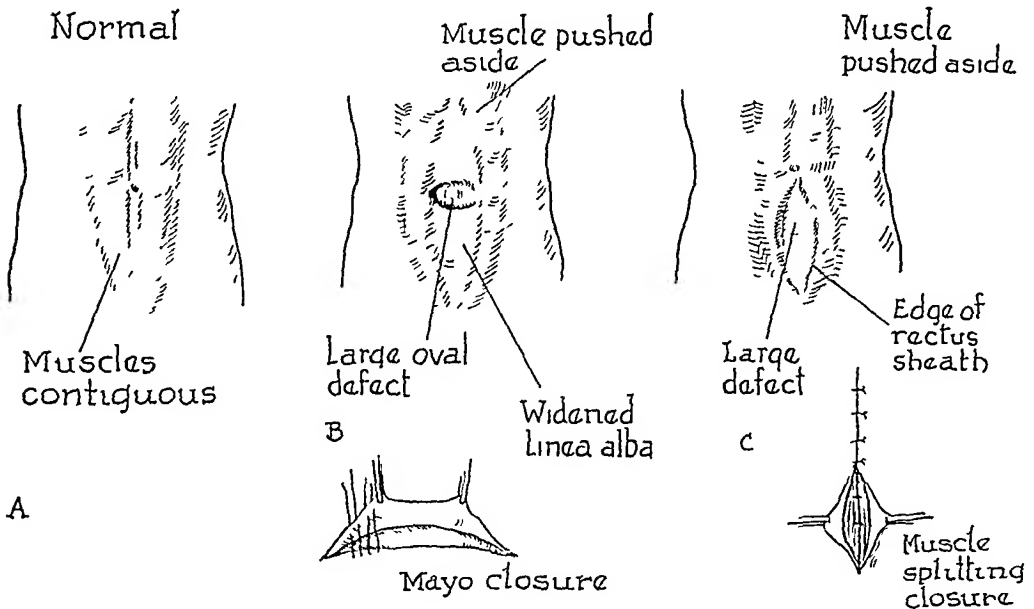


FIG. 2.—The recti muscles are separated from each other by only a narrow linea alba (A). Umbilical herniae, like herniae elsewhere in the midline, are due to defects in the linea alba. The rectus sheaths and muscles are pushed aside by enlarging herniae. It is desirable to bring the muscles back to their normal position. However the shape of the defect, the size of the patient, and other considerations are important in choosing the type of operation for a particular hernia. In large, oval defects wide transversely the Mayo closure is most efficient (B). In defects large in the sagittal plane (C) the Mayo operation is not applicable and splitting the rectus sheath with separate approximation of the posterior and anterior layers offers a strong closure.

tilages of the fifth, sixth and seventh ribs, and insert by tendons into the crest and the symphysis of the pubis.

Anatomically, the two recti muscles, within their sheaths, are close together with only a narrow intervening linea alba. The direct course of the muscles is deviated by large herniae. There are three factors mitigating against the reapproximation of the muscles at operation. One is the disproportionate size of the abdominal contents to the abdominal cavity in fat people, even when the hernia is reducible, another is the lateral pull of the lateral abdominal wall muscles, and a third factor is a broadened linea alba which itself disturbs the relationship of the border of one rectus sheath to another. In midline herniae the intact rectus sheath and rectus muscles are pushed aside by the hernia. The rectus sheath does not give way. The two sheaths are separated by the expanding hernial ring (Fig. 2). These facts are important in selecting a type of closure.

Not all midline ventral herniae can be closed most effectively, by the same type of operation. The type of operation most desirable is always the one offering the most anatomic closure with the least tension on the suture line. Many factors are involved including the size (weight) of the patient, the quality of the tissues, the location of the hernia in the upper middle or lower abdomen, and most important of all, the shape and size of the abdominal wall defect.

In repair of herniae between these muscles, the most desirable anatomic closure would be to reapproximate the sheaths of the muscles to form a new linea alba. This type of closure, however, has the disadvantage of constant counter tension on it from pull of the lateral abdominal muscles. The linea alba is a line on which the lateral abdominal muscles insert. Contrasting force is constantly being exerted at this line.

The defects of umbilical herniae are frequently almost round. Further stretching of the linea alba by obesity and enlargement of the hernia often results in distortion of the opening into an oval. When small, the defect can be closed by any number of methods, and the result can be expected to remain permanently good. If longitudinal approximation is chosen, the edges of the linea alba must be carefully freshened by cutting away the areolar tissue overlying the stronger fascia and the opening must be converted into a biconvex lens-shape.

Since umbilical herniae develop by eccentric expansion of the defect, Pólya³⁷ advocates closure of certain umbilical hernial defects by exerting an exact counter force. To accomplish this, he puts in a purse-string silk suture around the hernia opening and drawing this tight, closes the opening, getting equal tension from all sides (Fig. 1). I have employed this operation for a small umbilical hernia, and found the closure easily accomplished and very effective. Several reinforcing silk sutures are placed after the purse-string is tightened and tied.

In large, obese women, with protuberance of the abdomen, the recti muscles are more widely separated than normal. A wide, but fairly strong, linea alba effectively forms the abdominal wall above and below an umbilical hernial opening in such patients (Fig. 2). Here, any type of longitudinal approximation would result in considerable encroachment on the abdominal space. Part of the linea alba would have to be sacrificed to convert the opening into a shape which would permit even approximation of the fascia. In this type, a Mayo closure offers the best promise of lasting success. Less tension results. It is lateral tension more than longitudinal which embarrasses the cardiorespiratory system. Longitudinal tension can be relieved by merely flexing the patient, and thus shortening the distance between the xiphoid and the pubic bone.

In long, oval herniae, with the long axis in the sagittal plane, transverse closure may be undesirable because it may be difficult or impossible to perform. In nine cases of midline herniae, I have effected closure by the following procedure. In one of these patients the hernia was huge, as large as a man's head, with a defect 10 cm. in width and extending from the umbilicus to the

symphysis. The technic is as follows. A longitudinal incision is made extending well above and below the hernia. If it is an umbilical hernia, the skin incision curves around one side of the umbilicus and comes back to the midline (Fig 3). The umbilicus is not removed, but is turned aside, attached to one skin flap. It is sewed down to its normal position on closing. The incision extends down to the linea alba above and below the hernia, and the sac is carefully dissected free from surrounding tissues down to the aponeurotic ring. The subcutaneous tissue is carefully dissected away from the linea alba and the anterior sheath of the rectus. An incision is made through the midline and, after entering the abdomen, the incision is extended through the hernial ring and sac, carefully guarding against injuring any contents of

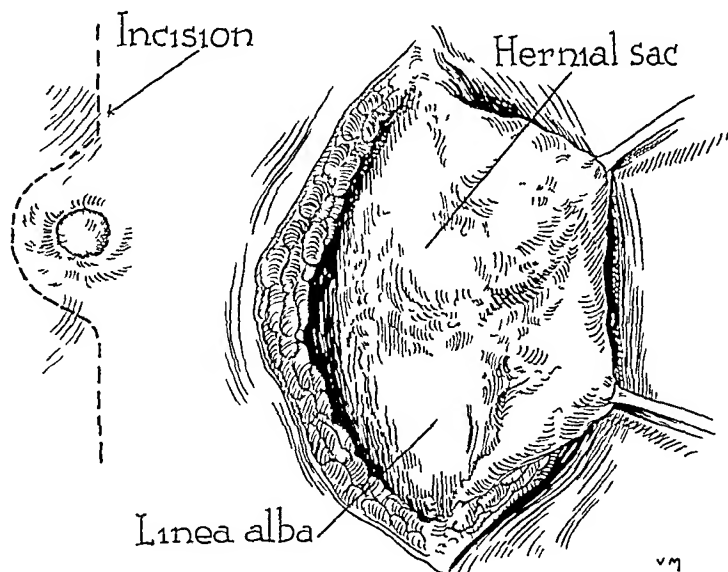


FIG 3.—In hernioplasty for umbilical hernia it is rarely necessary to remove the umbilicus. The umbilicus may be removed to advantage in massive herniae. In smaller herniae it may be left on one skin flap and sutured in its normal position on closing of the wound.

the hernia. The hernial contents are restored to the abdomen. The sac is removed. The edges of the hernial ring are cut away so as to remove any fat and areolar tissue. The rectus sheath is incised, in order to expose the edge of the muscle. The sheath on each side is then cut longitudinally at the junction with the linea alba, and the muscle is exposed for a considerable distance even above and below the hernial opening. The posterior rectus sheath is then closed with interrupted silk sutures. The edge of the muscles may then be approximated with a few sutures, or, the edge of the muscle may be caught in the same sutures which approximate the aponeuroses. Then, the anterior rectus sheath is closed with interrupted silk sutures. It is important to go well above and below the hernial opening, in order that the closure may be uniform and the slight necessary tension not irregular.

Geisuny³⁸ described a similar procedure in 1893. Apparently, it is uncommonly employed. It is anatomic and has a number of advantages. In my experience with it (nine cases) it has proved of decided value in long, oval, midline herniae, with the long axis in the vertical plane. It has these ad-

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advantages First, in large, longstanding herniae, after dissecting the sac free when the rectus sheath is opened, there is no doubt that true, good fascia is exposed The good fascia is thus not easily confused with a tough scar which might be regarded as the strong edge of the ring if a single fascial layer is intended Second, in closing posterior and anterior layers of the muscle separately, the tension is divided onto two lines of suture instead of

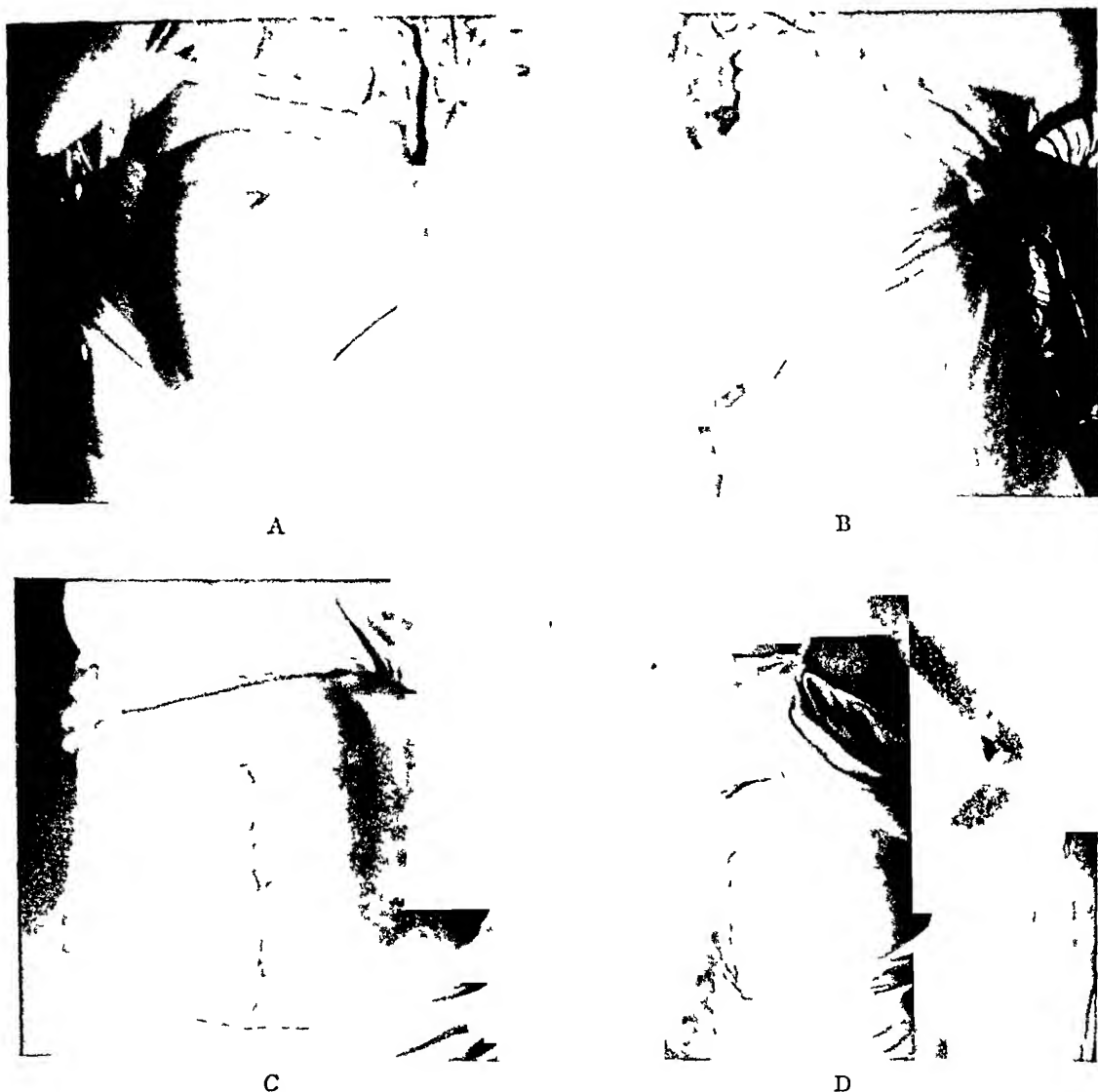
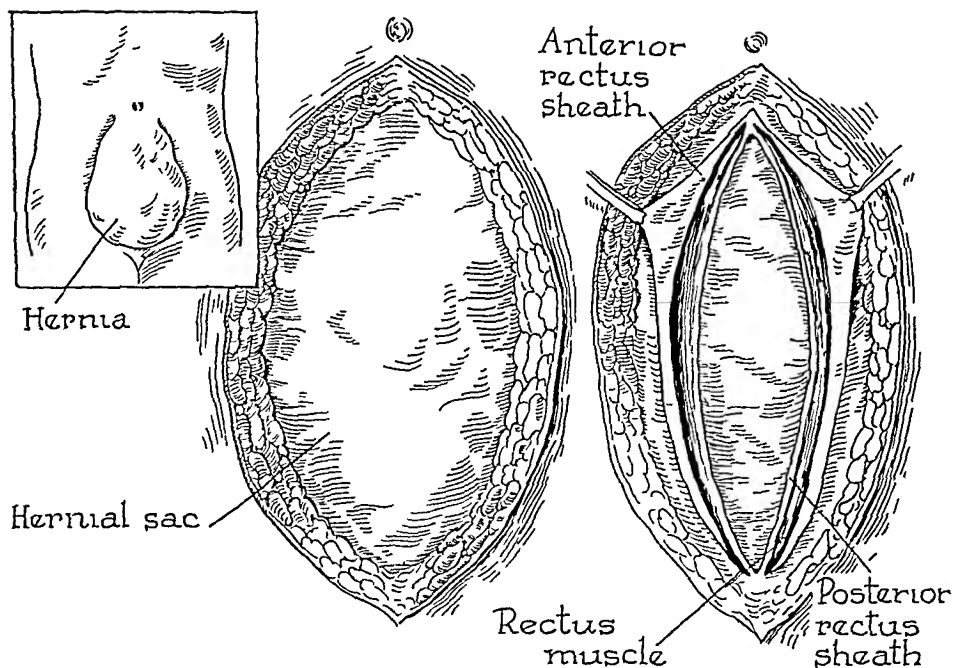


FIG 4—A very large midline ventral hernia A and B before operation, C and D, after operation The patient, age 47, had a celiotomy elsewhere, 18 years previously The hernia appeared soon thereafter, and has been present since The defect between the rectus muscle was 10 cm wide, and extended from the umbilicus to the pubis The patient was subjected to a period of preoperative preparation during which extra abdominal pressure was applied The closure was effected by splitting the rectus sheath Special fascial bands were placed to anchor the linea semilunares together (Figs 5, 6 and 7)

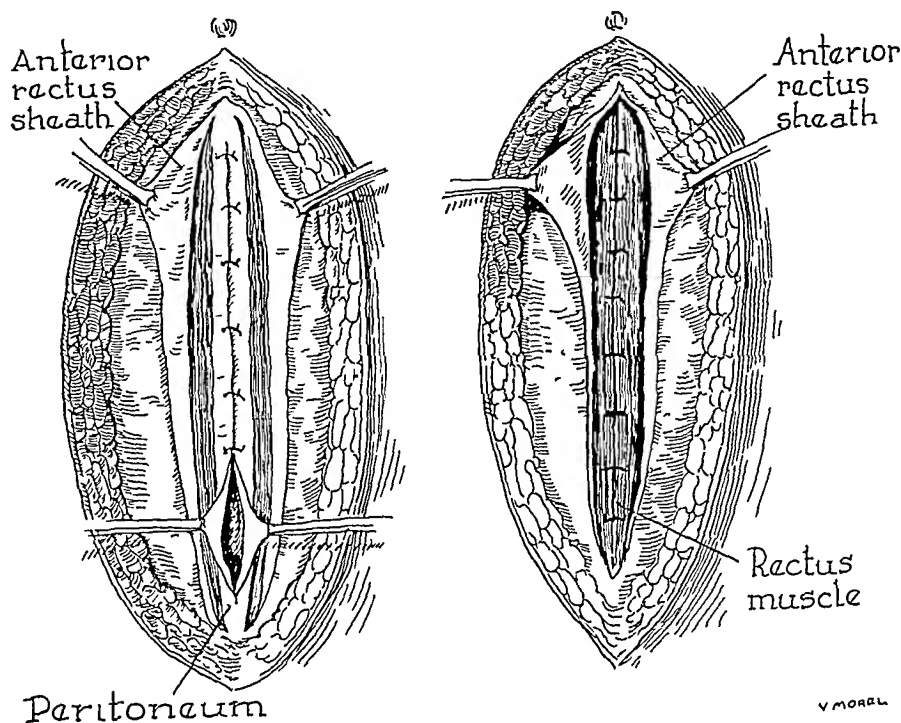
one The anterior suture line is under slightly more tension than the posterior Third, the muscles are brought nearer their normal position

In the case of a very large hernia (Fig 4), I have strengthened this type of repair with additional fascial strips transversely across the wound attached with silk to the anterior rectus fascia, far laterally, near the linea semilunaris (Figs 5, 6 and 7) The purpose of these fascial bands is not only to strengthen the wound where they cross, but, more important, to relatively fix one semi-



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FIG 5—This with Figures 6 and 7 illustrates the type of hernial repair applicable for the large ventral hernia such as in Figure 4. After incising the skin the subcutaneous tissue was dissected from the sac and laterally to the rectus sheath on either side. The firm edge of the hernial ring was exposed. The rectus sheath on each side was split on the mesial border. The muscle was thus exposed. After the hernia had been reduced the posterior sheath of the rectus was approximated with interrupted silk sutures in the midline (Fig 6). Several sutures approximated the muscles. After closing the anterior sheath of the rectus fascial strips were placed transversely as indicated in Figure 7. These were sewed to the anterior rectus fascia near the linea semilunares. The main purpose of these strips is to anchor one semilunar line to the other and thus relieve some of the tension on the hernial closure.



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FIG 6—See legend under Fig 5

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lunar line to the other, and keep them from separating, thus obviating any tendency to increased tension on the suture line by the pull of the lateral abdominal muscles. The tension, at the approximated fascia, is relieved by putting some of the pull further out near the linea semilunaris. These strips were placed by inserting them transversely across the wound. They went into the anterior rectus sheath and out, and in and across under the approximated anterior rectus sheaths and out, and in and out. The fascial strips were sewed to the anterior rectus sheath with silk at each place it went in, but at some distance lateral to the midline. After one side was sutured, the

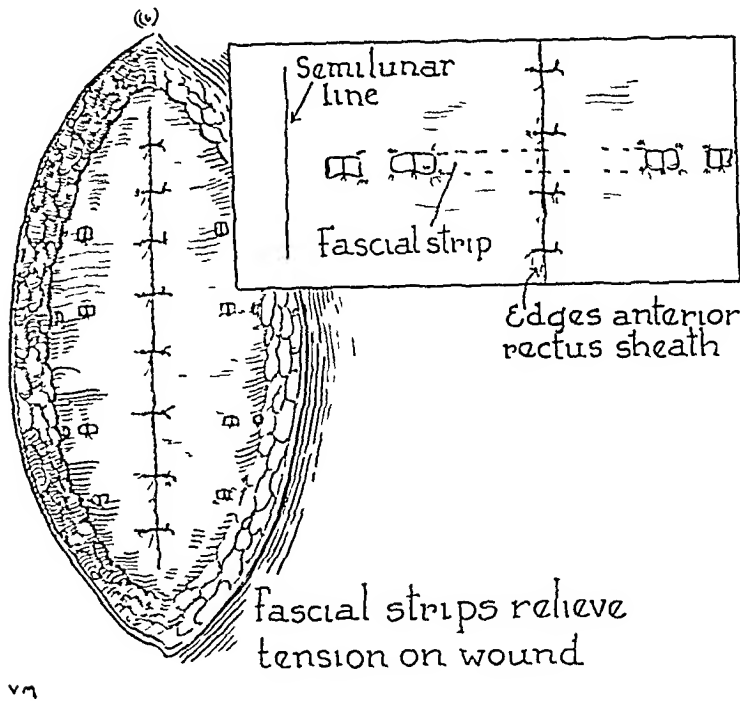


FIG. 7.—See legend under FIG. 5

strip was put under slight tension, and the opposite ends were sutured to the anterior rectus sheath. Four strong fascial bands were so placed. In this way, the fascial strips tended to hold the lineae semilunares toward each other. This operation is not recommended for repair of herniae with oval defects, wide transversely, and with a wide linea alba, where a Mayo type of closure can be employed to better advantage. It is best applied to defects longer in the long axis of the body where herniation is pushing the muscles apart.

In order to experimentally test the use of fascia as described, it was tried on the dog. One-half the width of the rectus muscle was removed, and the closure was effected by splitting the rectus sheath of the opposite side and approximating the posterior and anterior sheaths separately. Three fascial bands were placed as described, and anchored with silk, near the semilunar line. Three weeks later, examination showed the wound well healed. The fascia bands were living and apparently effective.

Proper postoperative management after hernioplasty for umbilical or mid-line ventral hernia is most important. The necessity of preventing ileus or

any distention, which might increase the tension on the suture line or embarrass respiration further by increased intra-abdominal pressure, is perfectly obvious. It is essential to restrict intake by mouth and employ constant Wangensteen's suction until any danger of ileus is passed. A binder should be applied to the patient as a protection from undue strain. It is probably a good measure to continue the use of this binder for at least two to six months after the operation, depending upon the size of the hernia. Obese patients should be cautioned that the danger of recurrence is increased by gain in weight. They should reduce, if possible. The period of rest in bed after a hernioplasty is variable. A safe period of rest in bed is from two to three weeks.

SUMMARY AND CONCLUSIONS

A brief review of the major advances in the surgical treatment of herniae is given. Since anatomic closure of hernial defects was described by Bassini and Halsted, it is realized that to cure hernia, the closure must be accomplished by approximating fascia to fascia, with a minimum amount of tension. Nevertheless, the incidence of recurrence remains high and hernioplasty is still not a perfect operation.

Various techniques are described for closing the defects in umbilical and midline ventral herniae. For small umbilical herniae, purse-string sutures or a number of other types of closure may be employed. For larger herniae, some type of longitudinal approximation of the edges of the rectus sheath or the linea alba is desirable. In very obese patients, with a widely spread linea alba, the Mayo operation is the least extensive and most efficient procedure. For closing hernial defects, long in the longitudinal axis of the body, with the hernia separating the recti sheaths, the Mayo operation is not applicable, and a classic repair must be made to approximate the abdominal wall in the midline. For this closure, the best procedure appears to be splitting the rectus sheath and separate closure of the posterior and anterior sheaths of the recti.

A method of relieving tension on the line of closure of the fascia is described. It consists of implanting transverse strips of fascia attached at some distance lateral to the line of closure. These prevent expansion of the relative distance between the linea semilunaris and thus tend to prevent increased tension on the suture line approximating the rectus sheaths.

The superior advantages of silk in the repair of hernia are emphasized.

It is rarely necessary to remove the umbilicus, in umbilical hernioplasty. The umbilicus can be saved on one edge of the skin. Its replacement has the advantage of being more cosmetic.

Fifty-seven cases of umbilical and midline ventral herniae operated upon at the Charity Hospital, New Orleans, were discussed. Umbilical hernia was more prevalent in the Negro race. A high incidence of obesity is found in patients requiring surgery for umbilical and midline herniae. Infections were more common after the use of catgut than after the use of silk. The Mayo

operation was most commonly employed. Next most frequent type of closure was longitudinal approximation of the fascia. Seventeen of the herniae were irreducible and 11 were strangulated. There were two deaths in the entire group and these followed operations upon strangulated herniae. Efforts to determine the end-results were not entirely satisfactory. The final results were ascertained in 11 cases following repair of an umbilical hernia. The hernia recurred in four instances.

REFERENCES

- ¹ Halsted, William S. The Radical Cure of Inguinal Hernia. Johns Hopkins Hosp Bull, 1, 12, 1889-1890.
- ² Halsted, William S. The Radical Cure of Inguinal Hernia in the Male. Johns Hopkins Hosp Bull, 4, 17, 1893.
- ³ Bassini, E. Über die Behandlung des Leistenbruchs. Arch f klin Chir, 40, 429, 1890.
- ⁴ Galen. Quoted by Francis Adams.
- ⁵ Celsus. Quoted by Francis Adams.
- ⁶ From the seven books of Paulus Aegineta with a commentary by Francis Adams (translated by Francis Adams), London. Printed for the Sydenham Society, 1844. On Exomphalos or Prolapse of the Navel, 2, Book 6, 340.
- ⁷ Petit, Jean-Louis. Oeuvres Complètes, 1837. Dans toutes les librairies médicales. The Reduction of Hernia by Operation, p. 656.
- ⁸ Cooper, Sir Astley (1768-1841). Hernia. From the second London Edition, Philadelphia, Lee & Blanchard, 1844. Chapter XIII, Umbilical Hernia, p. 259.
- ⁹ Malgaigne, J. R. Leçons cliniques sur les Hernies. Paris, Germer Baillière, 1841. Lectures delivered 1839-1840.
- ¹⁰ Franco, Pierre. Traité des hernies, 1561. Quoted by Malgaigne.⁹
- ¹¹ Heister, Lawrence. A General System of Surgery. 8th Ed. Trans. from the author's last edition, London, 1768.
- ¹² Scarpa, Antonio (1747-1832). Treatise on Hernia. Trans. by John Henry Wishart, Edinburgh. Printed for Thomas Bruce & Co., 1814.
- ¹³ Macready, Jonathan. A Treatise on Ruptures. London. Published by P. Blakiston & Co., Philadelphia, 1893.
- ¹⁴ Brun, B. Advantages of Subcutaneous Elastic Ligature in Treatment of Umbilical Hernia in Children. Arch de Med des Enfants, Paris, 15, No. 9, 641-720, 1912.
- ¹⁵ Storey, Horatio R. A New Operation for Umbilical Hernia. Med Rec, 1, 73, 1867.
- ¹⁶ Gorelow, M. A. Zur Anatomie des Nabelkanals. Arch f klin Chir, 181, 395-405, 1935.
- ¹⁷ Lucas-Championnière, J. La Hernie Ombilicale. Jour de Med et Chir, 66, 609, 1895.
- ¹⁸ Mayo, W. J. Radical Cure of Umbilical Hernia. ANNALS OF SURGERY, 34, 276, January, 1899.
- ¹⁹ McGlannan, Alexius. Massive Umbilical and Ventral Herniae. Surg, Gynec and Obstet, 20, 700, 1915.
- ²⁰ Stone, Harvey. Umbilical Hernia—A Method of Operative Treatment. Arch Surg, 12, 494, 1926.
- ²¹ Wathen, Wm. H. Umbilical and Ventral Hernia. Trans. So. Surg. and Gynec. Assn., 5, 75, 1892.
- ²² Johnson, Joseph L. Ruptured Umbilical Hernia. Trans. So. Surg. Assn., 14, 257, 1901.

- ²³ Werder, X O Case of Cesarean Section in Which the Uterus Was Incarcerated in a Ventral Hernia *Trans So Surg and Gynec Assn*, 21, 443, 1906
- ²⁴ Bartlett, Willard A Clinical and Experimental Study of Postoperative Ventral Hernia *Trans So Surg Assn*, 38, 453, 1915
- ²⁵ McGlannan, Alexius Lateral Ventral Hernia *Trans So Surg Assn*, 39, 162, 1926
- ²⁶ Pfannenstiel Über Schnitt und Naht bei gynakologischen Laparotomien *Zentralbl f Gynak*, 27, 399, 1903
- ²⁷ Graser, Ernest Zur technik der radical operation grosser Nabel-und Bauchwandhernien *Arch f klin Chir*, 80, 324, 1906
- ²⁸ Meleney, Frank Infection in Clean Operative Wounds A Nine-Year Study *Surg, Gynec and Obstet*, 60, 264, 1935 From the Surgical Service of the Presbyterian Hospital and the Bacteriological Research Laboratory of the College of Physicians and Surgeons, Columbia University
- ²⁹ Simmons, C D The End-Results of 70 Consecutive Cases of Umbilical Hernia Operated Upon at the Massachusetts General Hospital *Boston Med and Surg Jour*, 174, 342, 1916
- ³⁰ Longacre, A B Follow-Up of Hernia Repair *Surg, Gynec and Obstet*, 68, 239, 1939
- ³¹ Parsons, William B Silk Sutures in the Repair of Hernia *ANNALS OF SURGERY*, 106, 343, 1937
- ³² Gallie, W E, and LeMesurier, A B (Toronto, Canada) The Transplantation of the Fibrous Tissues in the Repair of Anatomic Defects *Brit Jour Surg*, 12, 289-320, 1924
- ³³ Gallie, William E Closing Very Large Hernial Openings *ANNALS OF SURGERY*, 96, 551, 1932
- ³⁴ Burdick, Paul G, Gillespie, David, Higginbotham, Norman Fascia Suture Operation for Hernia Summary and End-Results of 1,485 Operations *ANNALS OF SURGERY*, 106, 333, 1937
- ³⁵ Wangenstein, Owen H Repair of Recurrent and Difficult Hernias and Other Large Defects of the Abdominal Wall, Employing the Iliotibial Tract of Fascia Lata as the Pedicled Flap *Surg, Gynec and Obstet*, 56, 766, November, 1934
- ³⁶ Hahn, Johannes Die Radicaloperation der Überhernien mit Hilfe der Systematischen Dehnung der Bauchdecken *Arch f klin Chir*, 85, 718, 1908 (From the Private Clinic of Doctor Hahn, in Mainz)
- ³⁷ Polya, Professor Eugene Personal communication
- ³⁸ Gersuny, R Eine Methode der Radikaloperation grosser Nabelhernien *Centralbl f Chir*, 20, 921, 1893

DISCUSSION —DR BRADLEY L COLEY (New York, N Y) While I do not feel competent to discuss Doctor Guthrie's paper, I am very much interested in the subject, and wish to congratulate him on his presentation of it. These cases of hiatal hernia are usually treated at a general hospital but I believe if we keep a sharp lookout, we may find many more of them in our own practice.

Doctor Mahorner's paper was most interesting, and ably presented. We believe that these large ventral herniae should be given a longer period of pre-operative hospitalization than was heretofore deemed necessary. While undergoing a careful preoperative study, a low residue diet should be given. In getting the patient accustomed to the supine position, I believe, we have obviated some of the previously encountered pulmonary complications. Then, we have followed the lead of Potter, in that pitressin has been employed in these cases for from 48 to 72 hours after operation.

Relative to the suture material. For more than 20 years we have used kangaroo tendon, chromic catgut, living fascial sutures, and patch transplants,

running the whole gamut of changes of technic. We feel that the greatest single step forward has been in the adoption of the *silk* technic. The following lantern slide covering the classification of 1,000 consecutive cases operated upon at the Hospital for Ruptured and Crippled, in all of which silk was used, was then demonstrated by lantern slides and gave some conception of the percentage of recurrences. The latter is based upon cases actually followed. While the statistics may not seem credible, they are accurate. In fact, it has always been our policy to lean over backwards in presenting our statistics so that there may be no room for criticism. We do not regard a letter from a patient as satisfactory evidence of his condition. Each one is recalled to the clinic and examined not only by the surgeon who performed the operation but by a group of the staff members. Therefore, I feel that you can accept my statement without reservation, that the adoption of silk has resulted in a distinct improvement in our recurrence percentage rate. We know that it has markedly reduced the incidence of postoperative wound infection. Also, we have been impressed by the lack of reaction of the tissues to silk as compared to catgut.

DR ISIDORE COHN (New Orleans, La.) One thing I noted in both Doctor Mahorner's and Doctor Coley's statistics was the infrequency of epigastric herniae. Doctor Mahorner reported only four epigastric herniae and Doctor Coley had only seven. I believe these are a great deal more frequent than these statistics would indicate, and I think this is due definitely to the particular thing—that we do not routinely examine the abdomen for epigastric herniae. If we would palpate in the midline from the ensiform down, as some of us do, we would find a great many more.

We use practically that same method of opening the anterior sheath and using it as a second layer, as described by Doctor Mahorner. We have been doing that for seven or eight years.

DR CHARLES R. ROBINS (Richmond, Va.) I am much interested in the subject of ventral hernia. I will comment on only one thing, and I do this because I do not believe it has been adopted very generally. In these elderly, obese women who have those enormous herniae, any technic has to be carried out under tension.

Some four or five years ago there was published an article on the treatment of these herniae by suspending the patient in a sling which goes under the body and is attached to a line which runs over a pulley and on which hangs a weight. (Dixon, A. R. Postoperative or Ventral Hernia—A Method for Relief of Tension After Repair. Surg., Gynec. and Obstet., 61, 836, 1935.) It usually takes about 20 pounds to balance the muscular resistance. The advantage of this is that it brings up the loins in this way, and tends to bring the tissues together, so that when the wound is closed, instead of having to close it under tension you are able often to overlap the fascia. Where I have used it, it has worked remarkably well.

DR HOWARD MAHORNER (New Orleans, La., in closing) I want to thank the members who discussed my paper. I am glad Doctor Coley could demonstrate so much better by his statistics my favorable impressions concerning the use of silk. It is my choice of suture material in these cases. So far as the type of operation described is concerned, it, incidentally, is not entirely new. Splitting the rectus fascia was first described in 1894 by Gersuny, of Vienna. Undoubtedly it has been employed many times since. Although one may have the impression he is using something different, in this instance some of the essential features have been described before.

HEMOLYTIC JAUNDICE¹

ADDISON G. BRENNER, M.D.

CHARLOTTE, N. C.

HEMOLYTIC JAUNDICE is a disease primarily due to increased fragility of the erythrocytes and characterized by anemia, increased destruction of the red blood cells, acholuric icterus, splenomegaly and a pronounced increase in the reticulocyte count. Doan¹ states positively that "true hemolytic icterus is always the manifestation of an inherited constitutional defect, characterized, when clinically active, by recurring crises of deglobulization, anemia, increased erythrocyte fragility, and unusually high reticulocytosis, acholuric icterus and splenomegaly." As Nesler² aptly says "Both congenital and acquired forms of the disease are recognized. The principal difference between the two is the age at the time of onset, in general, the course of the acquired form is more severe." The diagnosis is made from the history, the detection of a symptomless mild jaundice (more or less severe) and an enlarged spleen, and from laboratory examinations. The urine does not show bile, but contains an excessive amount of urobilinogen and urobilin, as do the feces. The icterus index may be increased to 100, the indirect van den Bergh reaction is positive, the direct reaction is negative. The reticulocyte count is between 5 and 35 per cent in most cases, but may rise as high as 95 per cent. The fragility of the erythrocytes is increased to between 0.6 and 0.4 per cent (normal 0.42 to 0.3 per cent).

The following is a citation of four cases of the congenital (familial) type and two cases of the so-called acquired type. The six cases illustrate most of the findings in hemolytic jaundice (icterus, anemia).

Case 1 is the brother, brother and uncle, respectively, of Cases 2, 3 and 4. He (brother, brother and uncle) died in the hospital while being prepared for a splenectomy. The fact that he died "while being prepared" for a splenectomy might be explained in my Case 5 of the so-called acquired type and the two cases recently cited by Sharpe and Davis,³ where hemolysis was increased by the giving of blood.

I continue to use the adjective "so-called" before the acquired type because I am taking Doan's word for it that among the cases followed by him, when properly tested, the congenital and acquired types seemed to be the same entity more or less exaggerated, differing also in the time of appearance. From the standpoint of heredity, he claims that the disease may be passed without being made evident in the individual, certainly not recognized without hematologic studies. The two acquired cases recited in my group of six cases of hemolytic jaundice would seem sporadic and individual so far as a thorough inquiry into the two family histories would show, both as to ancestry and posterity. I must

* Read at the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

let the reader choose for himself a familial hemolytic jaundice, becoming evident sooner or later, of two distinct types (1) The congenital or familial, and (2) the acquired type. My conviction is that there is an acquired type much more severe than the congenital or familial type. It is true, on the other hand, that the brother, brother and uncle, who died when he was being prepared for a splenectomy, was an acquired type until jaundice and anemia proved to the brother, sister and brother's daughter that they had the same disease. Hereafter, they had all been treated for attacks of malaria.

CASE REPORTS

Case 1—This patient was a brother of Case 2 and brother and uncle, respectively, of Case 3 and Case 4. He was a white man, age 38, and died at the Charlotte Sanatorium, September 29, 1920, while being prepared to be operated upon. He was jaundiced and pale, and had a large mass in his left side. He had had many attacks of jaundice, pallor, fever, and pain in his left side. This last attack was his worst. There was some confusion about whether this mass was kidney or spleen. While the case was still being considered he died.

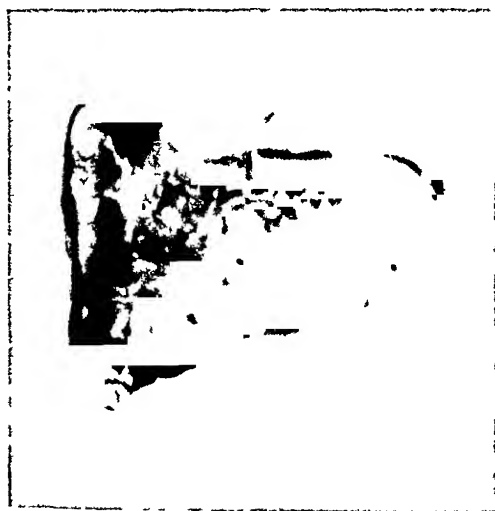


FIG 1—Case 2 Spleen weighing 1,240 Gm

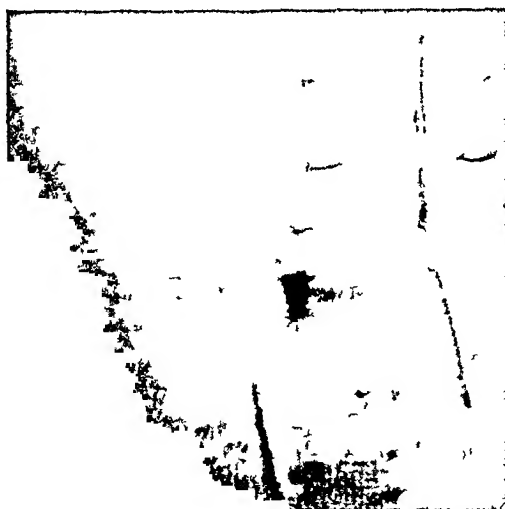


FIG 2—Case 2 Sister of Cases 1 and 3, and aunt of Case 4. During convalescence developed pain in abdomen and temperature. At second operation a widespread lymph node adenopathy was found. Refer also to Ingrassia's case for a similar condition after treatment of dementia paralytica with malaria.

Case 2—This patient was a sister of Case 1, sister of Case 3, and first cousin of Case 4. She was a white matron, age 27, and stated that all the above named persons were thought to have "bilious spells from malaria," and the eight-year-old niece had worms in addition. (In fact, she vomited a long, living round-worm the third post-operative day.) Married seven years, and has two children, one five and one two years, both in good health.

Patient has had "bilious spells," when she became yellow, temperature rose and she had pain across her upper abdomen. She noticed a large mass in her left upper abdomen two years ago. She says that she was toxic during both pregnancies. For four or five months, has felt exhausted all the time.

Physical Examination—May 25, 1938. The patient was a young woman obviously anemic, her skin of a lemon-yellow color, mucous membranes, palms and soles quite pale. Spleen greatly enlarged, reaching to midline. She had already received (May 23, 1938) 300 cc of citrated blood and the following day 525 cc. Temperature rose to 102°

and 103° F On June 14, 1938, a splenectomy was performed (Fig 1) She was operated upon again 22 days later (July 6, 1938), and the surgeon wrote upon his operative record "Widespread mesenteric adenitis—probably malignant" Appendicectomy, closure On July 20, 1938, it was noted on the chart that "Following operation, the patient made an uneventful recovery for about ten days, and then began to have some severe abdominal pain and nausea, but obstinately constipated, had constant severe soreness and exquisite tenderness over the entire abdomen, but particularly marked in the lower right quadrant Wound appeared clean, pelvic examination negative These symptoms persisted with increasing intensity, and it was decided to operate The abdomen was opened and a widespread mesenteric adenitis was found, the source being a badly infected appendix, following removal of the appendix, an uneventful recovery followed, and she was allowed to leave (July 20, 1938), much improved and wound entirely healed" (Fig 2)



FIG 3—Case 3 Brother of Cases 1 and 2 and father of Case 4



FIG 5—Case 3 Patient one year later with oblique incision well healed, but still showing one year later fragility of the red blood cells

This widespread mesenteric adenitis is very interesting, showing again how, in the absence of the spleen removed 22 days before, the lymphatic system compensates or takes on some function of the spleen A general lymphadenopathy, enlarged liver and absolute lymphocytosis during the course of paroxysms of chills and fever were reported by Ingalls⁴ in a patient without a spleen, treated for dementia paralytica by the induction of malaria

The laboratory work on Case 2 before she had blood transfusions, May 21, 1938, showed Entirely negative urine, no bile, W B C 4,150, R B C 2,990,000, Hb 11.2 Gm per 100 cc (73 per cent), polys 82, lymphs 17, large mononuclears and transverse 1 per cent, erythrocytes, great variation in size, many large and many small R B C, shape normal, Hb content high

After 825 cc of blood, May 23, and 24, 1938 Urine, no bile, urobilinogen faintly positive Blood Reticulocytes 2.5 per cent, icterus index 14, van den Bergh direct, immediate negative, delayed negative, indirect positive, no malaria parasites Fragility test Hemolysis begins at 0.44 (normal 0.42–0.44), hemolysis complete at 0.32 (normal 0.32–0.36)

Blood work, September 10, 1938 Hb 85 per cent, R B C 5,600,000, W B C 11,700—n 66, l 26, e 1, mon 7, b 0, platelets 275,000 Fragility test Hemolysis begins 0.5, hemolysis complete 0.38, control 0.42–0.34

On September 10 and December 30, 1938, patient looked quite well, and said she felt better than ever before in her life

Case 3—This patient was a brother of Case 1, brother of Case 2, and the father of Case 4 He was age 35 (August 25, 1938), had been married ten years, and had three

HEMOLYTIC JAUNDICE

children One child, a brother and a niece have the same trouble that he does Large mass in left side, which is painful when he has attacks (Fig 3) Three attacks a year Jaundice, pain in upper abdomen and kidney region, headache, nausea, vomiting and fever These attacks are not more frequent lately, but are more severe Had two ulcers of left leg that healed after splenectomy Temperature 99° F, pulse 70, respiration 20, blood pressure 120/70, W B C 8,500—n 84, e 2, mon 2, s 2, R B C 3,200,000, Hb 65 per cent, platelets 270,000 Wassermann negative, Kahn negative No parasites in blood and stools Urine negative, no bile (For some unknown reason fragility test not done) Operation, September 5, 1938 Transverse incision, splenectomy (Fig 4)

Blood work, December 30, 1938 Hb 90, R B C 4,650,000, W B C 10,500—n 74, l 14 e 4, mon 8, b 0, platelets 360,000 Fragility test Began 0.5, complete 0.4, control 0.42—0.34 Patient physically quite well, and says he feels well (Fig 5)

Case 4—This child, 8 years old (August 30, 1938), was the daughter of Case 3, niece of Case 1 and Case 2 She has had practically the same history of attacks as other members of the family, and everybody in the family is sure she was born with jaundice, and that her attacks are more frequent and very severe She passed a lot of round-worms The other two children have had no such attacks She is now beginning to have an attack

Blood work, July 14, 1938 Hb 50 per cent, R B C 3,100,000, W B C 11,600—n 91, l 5, e 3, mon 1, b 0, platelets 240,000 Fragility test Hemolysis begins 0.52, complete 0.38, control 0.42—0.34



FIG 4—Case 3 Spleen weighing 1,100 Gm



FIG 6—Case 4 Daughter of Case 3 Niece of Cases 1 and 2



FIG 8—Case 4 Showing the oblique incision one year later Still shows mild fragility of the red cells

August 30, 1938 Patient jaundiced, pale, temperature 101° F, vomiting, large painful spleen (Fig 6) Operation, August 31, 1938 Transfusion 300 cc blood and splenectomy (Fig 7) Uneventful course (Fig 8) except a rise of temperature to 104.6° F on the day of operation, and again to 101° F on the third day, when she vomited a long round-worm

Blood work, December 30, 1938 Hb 85 per cent, R B C 4,500,000, W B C 17,000—n 77, l 21, e 0, mon 1, b 1, platelets 300,000 Fragility test Began 0.5, complete 0.38, control 0.42—0.34

The weight of the spleen in these cases varied from 1,145 to 300 Gm *Microscopic Examination* (Dr L C Todd) (The descriptions of the three spleens were almost exactly the same) Engorgement of reticular meshes, venous spaces showing relatively little blood There is a hyperplasia of the reticulum cells seen in areas where the hyperemia is less intense, and there is a generalized lymphoid hyperplasia of the malpighian corpuscles Enlargement of the spleen is due to engorgement and hyperplasia There is increased blood destruction as evidenced by erythrophagocytosis and siderosis

(Fig 9) *Pathologic Diagnosis* These findings are those of constitutional, hemolytic anemia ("familial hemolytic jaundice") but would have to be proven by clinical and hematologic criteria

Case 5—April 28, 1924 White, unmarried farmer, age 31, with marked anemia Has been weak and pale for 18 years—the condition varies, has been very severe for past several months Dr William Allan "This man presents a striking appearance—tall, thin, ghastly pale with deeply bronzed face and hands, is evidently weak, short of breath, with swollen ankles Temperature 100° F, pulse 90, blood pressure 105/50 Abdomen full, with thin walls The spleen extends to the crest of ilium, edge of liver palpable, abdomen otherwise normal



FIG 7—Case 4 Spleen weighing
1 000 Gm

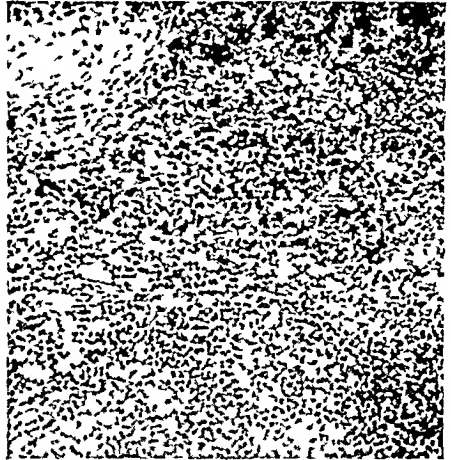


FIG 9—Case 4 Section typical of spleens in hemolytic jaundice Splenic tissue filled with deglobulized red cells and pigment, increase in reticulocytes, malpighian corpuscles swollen The spleen in hemolytic jaundice is remarkable for its lack of specific pathology

"Blood work W B C 6,300—n 72, l 25, e 1, b 1, myelo 1, a few normoblasts, R B C 1,352,000—red cells show very marked variation in shape size and staining, Hb 30 per cent, color index 1.1 per cent Fragility test Began 0.4, complete 0.32 Blood serum tested for bile and found positive Urine negative for sugar, albumin, indican and bile Urobilinogen strongly positive



FIG 10—Case 5 15 years after splenectomy
Blood picture, including fragility normal

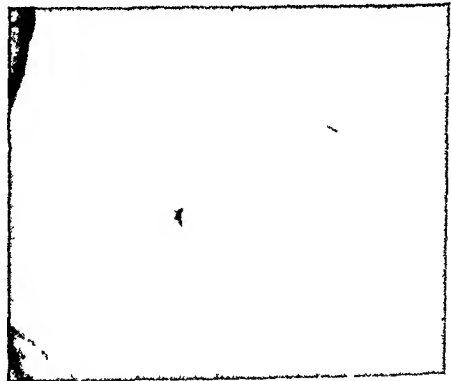


FIG 11—Case 6 Five years after splenectomy Blood picture normal including fragility The two later cases Cases 5 and 6, show a split muscle (Bevan) incision

"A severe hemolytic anemia, which shows a blood picture of pernicious anemia, but the clinical picture is that of hemolytic icterus"

Starting with 1,352,000 red cells and 30 per cent hemoglobin, after several massive blood transfusions—one given the day before and one on the day of operation—the red

count was 1,696,000, Hb 30 per cent, whites 6,900 This phenomenon is further explained by Sharpe and Davis.² Splenectomy was performed, June 17, 1924

Blood 14 days later R B C 4,336,000, Hb 65 per cent, W B C 12,200—n 61, l 29, e 3, b 7, no nucleated reds, color index 0.75

January 8, 1939 R B C 5,600,000, Hb 100, W B C 7,900—n 69, l 27, e 1, m 3, platelets 360,000, fragility 0.46–0.34 Patient in excellent health (Fig 10)

In this case, apparently, the red cells were destroyed as rapidly as they were transfused and the patient gained nothing until his spleen was removed The point made here is further clarified by the recent paper of Sharpe and Davis,³ explaining severe reactions following transfusion in hemolytic jaundice

Case 6—August 13, 1934 A white matron, age 61 Complaint Jaundice, paleness, weakness, gas pains in upper abdomen, large mass in left upper abdomen, which she noticed for some years Has been getting paler, more jaundiced and weaker for the past few months She has had her gallbladder drained no stones were found She has had five transfusions, receiving 2,500 cc of blood, but continues to destroy her red blood cells Temperature 100.2° F, pulse 100, respiration 20, blood pressure 120/70 Abdomen Very large hard mass, emerging from left costal margin and extending below navel, notch can be felt and seems fixed under ribs (large spleen)

Blood work, August 6, 1934 R B C 1,200,000, Hb 39 Gm per 100 cc (28 per cent) Schilling hemogram 0, 0, 2, 5, 10, 45, 37, 1, reticulocytes 40 per cent, icterus index 32.5

There is a marked decline in megalocytes, an occasional normoblast Reticulocytes 40 per cent, and majority are very young forms With the rapid formation of the red cells, there must be a very rapid hemolysis of the patient's own cells to keep the red count so low Marked hemolytic jaundice Fragility test 0.5–0.36 Wassermann, Kolmer, Craig, Kline and Kahn negative Operation, August 15, 1934. Splenectomy (Fig 11) Spleen Weight 1,140 Gm, 24×12×7 cm, 180 cc of blood drained when hilus ligation is removed Enlargement with retention of normal shape, no nodules, no tubercles Capsule thin and smooth, no peritoneal adhesions Of firmer consistence than normal Cut surface shows a deep-red pulp with widely separated and prominent follicles

Microscopy The follicles are widely separated, the pulp is crowded with red blood cells, though the sinuses are relatively empty The reticulo-endothelial cells are large oval and crowded with blood pigment The reticulum and trabeculae are not thickened

November 22, 1935 R B C 4,240,000, Hb 116 per 100 cc (84 per cent), W B C 7,050—dif (Schilling hemogram) 0, 0, 0, 5, 2, 43–49, 1

Excerpt from patient's letter, January 4, 1939 "I have completely recovered (Fig 11), and am getting along well"

Discussion—Case 2 (It will be noted that this case was operated upon by another surgeon) Shortly after her splenectomy, her temperature rose, her abdomen became tender and under the diagnosis of appendicitis, another celiotomy was performed, the surgeon vaguely described an involved appendix and mesenteric nodes due to it Looking further, he found many mesenteric nodes which he described as cancer Ingalls⁴ case of induced malarial infection in the treatment of dementia paralytica, where the spleen had previously been removed, not only recovered and was benefited, showing the plausibility of the treatment, but gave evidence of a general lymph node enlargement, more so on account of the absence of the spleen—the blunt of resistance to the in-

fection being taken by the reticulo-endothelial system. The eight-year-old child, Case 4, and niece of the patient, Case 2, who was operated upon at the beginning of a hemolytic crisis, likewise exhibited a rise in temperature and abdominal tenderness, which subsided during the course of her recovery. Several authors, including myself, are aware that the restoration of erythrocytes is, in these cases of hemolytic jaundice, not a gradual process, but, on the other hand, very rapid, a million or more cells gained to the blood stream while the patient is on the table during the course of the splenectomy. It would be interesting to be able to follow the changes, particularly in the bone marrow, lymph nodes and liver, under this sudden revolution brought about by the splenectomy. This autotransfusion and deluge of red cells into the blood stream is life-saving, as in Case 5 of this series, where the man was not only not benefited by transfusions, but, as was remarked at the time "He not only hemolysed his own red cells but those from other donors."

I feel sure that further study of the entire reticulo-endothelial system, bone marrow and liver might aid us in establishing a more definite pathologic groundwork for hemolytic jaundice, especially since the organ removed, while bulky enough—plenty of meat, in other words—shows so little in its histopathology. The fact that it shows so little beyond the engorgement with remnants of erythrocytes and their pigment is one of the most characteristic points in the pathology of the spleen in hemolytic jaundice. The liver and kidney are often as much pigmented, and the liver, as indicated in the photographs of Cases 3 and 4, father and child, is considerably enlarged before splenectomy, and of normal size four months after operation. It is likewise known that gallstones and evidence of cholecystitis figure high in cases of hemolytic jaundice.

Since the removed organ, the spleen, has so little to show for itself pathologically, but since its removal usually brings about a cure of the case of the former syndrome suffered from, what, then, has stopped the destruction of red blood cells? Does their destruction, their deglobulization, depend upon their inherited or acquired quality of being more fragile? If their destructibility is dependent upon the erythrocytes' fragility, what is removed with the spleen to do away with the syndrome of symptoms formerly suffered by the patient, while the erythrocytes may still show considerable fragility and may hemolyze in hypotonic salt about as they did before operation? And finally, while congenital and acquired hemolytic jaundice are chronic and a certain amount of deglobulization is going on all the time, one of the characteristics of the disease is the attacks or crises of erythrocyte destruction, when the jaundice and anemia are more intense, when the liver and spleen are much larger, in fact, when the spleen is quite large, painful and sensitive, when the temperature rises several degrees. These crises subside and those who have acquired the disease early, as in Cases 2, 3 and 4, who have had it as far back as they can remember, and the father and aunt claim the child was born jaundiced, get along fairly comfortably and live well into maturity. What, then, determines the crises in these cases? Let it not be supposed that these crises are

without danger. The reader will recall that Case 1—the brother, brother and uncle of Cases 2, 3 and 4—died while being prepared for splenectomy, that in Case 5 the patient's life was barely saved by splenectomy, and that he and Case 6 have lived 15 and 5 years, respectively, in excellent health.

The spherocyte was first described by Naegeli, and he suggested that it was pathognomonic of hemolytic jaundice. Gansslen⁵ made much the same observations.

Conclusions of Castle⁶ "The following results suggest that differences in the susceptibility of various types of erythrocytes to hemolysis by hypotonic salt solution are due largely to differences in form, and not to differences in osmotic behavior.

(1) "The percentage increases in equilibrium volumes in hypotonic plasma of erythrocytes of widely different susceptibilities to hemolysis do not show significant differences.

(2) "Direct microscopic observations indicate that (a) Hemolysis of a given type of erythrocyte is associated with the assumption of a spherical form in hypotonic plasma. (b) The more susceptible the erythrocyte to hypotonic hemolysis, the less hypotonic is the plasma necessary to cause the assumption of a spherical form.

(3) "An approximation to the percentage increase in volume necessary to cause hemolysis can be made by calculation of the percentage difference between the volume of the erythrocyte in isotonic plasma, V_o , and that of a sphere of equal surface, V_s .

(4) "In correlations of the relative degree of susceptibility to hypotonic hemolysis of a series of types of erythrocytes with their respective volume, diameter or surface in isotonic plasma, the erythrocytes of hypochromic anemia and of chronic hemolytic jaundice present exceptions.

(5) "When such correlations are made on the basis of the diameter, thickness ratio, or when absolute values are calculated according to the formula, $\frac{V_s - V_o}{V_o}$ the erythrocytes of hypochromic anemia and of chronic hemolytic jaundice do not present such exceptions.

(6) "Differences in the time necessary to cause hypotonic hemolysis of different types of erythrocytes may possibly be explained by differences in the percentage increase in volume of the discoidal form necessary to produce the spherical form in hypotonic solution."

Conclusions of Damshek, Schwartz and Gross⁷ (1) "Isohemolysins of the immune-body type were discovered in the serum of three cases of acute hemolytic anemia.

(2) "Antiguinea-pig hemolytic serum was prepared by the injection of guinea-pig red cells into rabbits. This serum possessed all the immunologic properties of the serum found in the clinical cases.

(3) "Hemolysis of the red cells of the guinea-pig *in vivo* followed the injection of this serum.

(4) "By varying the dosage of the antiguinea-pig hemolytic serum, various types of hemolytic syndromes were produced. Fulminating hemolytic anemia with hemoglobinuria, acute hemolytic anemia, and subacute hemolytic anemia.

(5) "Various types of blood pictures could be reproduced at will. Microspherocytosis, increased erythrocyte fragility, reticulocytosis, 'pseudomacrocytic' blood picture, *etc*

(6) "The spherocyte is a small, thick, red blood cell, unaltered in volume though small in diameter, and unusually fragile to hypotonic salt solution. Our observations point to the conclusion that spherocytosis is due to the activity of hemolysin and not to an abnormal anatomic peculiarity or to a disturbed formation of cells in the bone marrow. Since increased fragility is a function of the increased thickness of the red cell, it is dependent upon the same cause.

(7) "We believe that hemolytic syndromes are due to hemolysins, possibly of different types and present in different amounts, functioning slowly in some cases and violently in others. The various blood pictures of the hemolytic anemias, namely, anemia, spherocytosis, increased fragility and reticulocytosis, are, in all probability, due to the effects of the varying activity of hemolysins, and modified by the individual's power to react.

(8) "Since the experimentally produced hemolytic syndromes and the numerous clinical types are closely comparable, the chief difference in the clinical syndromes may be a matter of the amount of functioning hemolysin present."

Surgery of the spleen has had its trials, as seen by the tables from the Mayo Clinic. Surgery now would be offered, in carrying out its greatest triumph, in the following conditions: Ruptured spleen, hemolytic jaundice, splenic anemia and hemorrhagic purpura.

The literature has again become replete with transverse incisions, instead of perpendicular ones, just as happened during the war period. The truth of the story is that we all have had an incision "bust wide open in our faces" occasionally, and then go about, as sort of an excuse, to show what we know about the abdominal wall. I am now anxious to show you some of my transverse incisions. Some of the spleens are so large that two transverse incisions run together by a connecting bar might be necessary to deliver it and restore the abdominal wall without a hernia. The reproach of a hernia is felt keenly by all surgeons, especially when secondarily repaired by another surgeon.

The trick of ligating the splenic artery, quite a large vessel, in gross splenic enlargements saves one the embarrassment of hemorrhage, if not jeopardy to the patient.

On account of severe hemorrhages from the lower esophagus in splenic anemia (Banti's disease in the late stages) before and after a splendid result from splenectomy, it has been suggested that the coronary vein be ligated, in order to lessen the venous turgescence by breaking the communication with the portal circulation.

To promote additional collateral circulation, which, in fact, is Nature's means of relieving portal obstruction, some form of omentopexy might be performed, such as that of the Thalma-Narath or the modification recommended by Pemberton

CONCLUSIONS

(1) Hemolytic jaundice is an entity and should be easily recognized by appreciating the following syndrome: Acholuric jaundice, enlarged spleen, anemia, crises with pain and fever, increased fragility of the red cells, increase of reticular cells, urobilin but no bilirubin in the urine, normal colored stools, increased icterus index, negative direct van den Beigh with positive indirect van den Beigh reaction, and absence of itching. The congenital or familial type may embrace all cases.

(2) The blood picture: "We believe that hemolytic syndromes are due to hemolysins, possibly of different types and present in different amounts, functioning slowly in some cases and violently in others. The various blood pictures of the hemolytic anemias, namely, anemia, spherocytosis, increased fragility, reticulocytosis, are in all probability due to the effects of the varying activity of hemolysis, and modified by the individual's power to react."

(3) Splenectomy offers its greatest triumph in the treatment of (1) ruptured spleen, (2) splenic anemia (late stage Banti's disease), (3) hemolytic jaundice, and (4) purpura hemorrhagica. There are few operations as dramatic as splenectomy for hemolytic jaundice and for purpura hemorrhagica—where in the one instance there may be a gain of a million red cells, and in the other a stopping of bleeding while the patients are still on the operating table.

REFERENCES

- ¹ Doan, C. A. Pathologic Physiology of the Spleen, Rationale of Splenectomy in Congenital Hemolytic Icterus, Thrombocytopenic Purpura, and Early Banti's Disease. *Northwest Med*, 37, 61, March, 1939.
- ² Nesler, A. B. Chronic Hemolytic Jaundice, Cure by Splenectomy. *Jour Iowa Med Soc*, 28, 103, March, 1938.
- ³ Sharpe, J. C., and Davis, H. H. Severe Reactions Following Transfusions in Hemolytic Jaundice. *J A M A*, 110, 2053, June 18, 1938.
- ⁴ Ingalls, G. S. Induced Malaria in a Patient Without a Spleen. *J A M A*, 111, 700, August 20, 1938.
- ⁵ Gansslen, M. Hemolytic Jaundice. *Deutsche Arch f Klin Med*, 140, 210, September, 1922.
- ⁶ Castle, W. B., and Goland, G. Susceptibility of Erythrocytes to Hypotonic Hemolysis. *Am Jour Physiol*, 120, 371, October, 1937.
- ⁷ Damshek, W., Schwartz, S. O., and Gross, S. Hemolysins as the Cause of Clinical and Experimental Hemolytic Anemias. *Am Jour Med Sci*, 196, 769, December, 1938.
- ⁸ Dedichen, H. G. Hemolytic Icterus and Ulcers of the Lower Leg. *Acta Med Scandnav*, 77, 411, May 6, 1931.

DISCUSSION—DR J. D. RIVES (New Orleans, La.) I can make no contribution to Doctor Brenizer's discussion of hemolytic jaundice, but I would

like to ask him a question which I have found unanswerable. It seems reasonable to believe, in view of the work of Naegeli, Haden and others, that the tendency to hemolysis in hemolytic jaundice is due to the spherocytosis. It would seem that Haden has proved that the increased fragility of the red cells is due to their spherical shape, and that only these cells are hemolyzed. It also seems well established that the spherocytosis and the accompanying increased fragility of the red blood cells persist indefinitely after splenectomy. Doctor Brenizer reports that after transfusion, hemolysis was increased and that, as a result, the liver became much increased in size. This observation has been made by numerous other observers, and we have been warned against the danger of anemia resulting from this excessive hemolysis. If the spleen is innocent and hemolyzes only the spheroidal cells, why does excessive hemolysis occur following a transfusion of blood in which there are no spheroidal cells? I have been unable to find an answer to this question and hope that Doctor Brenizer has been able to do so.

DR FRANK H LAHLY (Boston, Mass.) I would like to take this opportunity to mention something not particularly related to the subject, but because the question of splenectomy comes up in Banti's disease. I want to remind you of the value of heparin. While splenectomy is now performed in fewer cases of Banti's disease, heparin has been of great value to us in those cases in which the operation is indicated. Certainly, some of our troubles following splenectomy in Banti's disease have been due to thrombosis. Heparin is of value not only in cases in which the number of platelets increases from 35,000 to 500,000 in a few hours, but particularly in those in which pyelephlebitis occurs during recovery. Nothing can be done for that, but here is something that offers hope. Heparin inhibits the formation of a clot, and is of definite aid, particularly in those cases in which the splenic vein is already thrombosed and further extension of the thrombosis is taking place.

DR WALTER D WISL (Baltimore, Md.) Several years ago I reported, before this Association, six cases of hemolytic jaundice in the same family, with splenectomy in each instance, and I simply want to bring the record up to date for the transactions of this organization. I have now performed seven splenectomies in this family and three in another, with two other cases of hemolytic jaundice in the second family that have not yet been operated upon.

DR FOY ROBERSON (Durham, N. C.) I am very glad to hear this paper. To-morrow morning I have a little paper on "Solitary Cyst of the Spleen" and I am sorry they do not come together. I do not want to give the impression that I know anything about the spleen. However, I believe this paper should stimulate some interest in that subject. I think probably the whole question of surgery of the spleen will have to be rewritten. From 1930 to 1934, at the Mayo Clinic there were some 650 splenectomies, the majority for hemolytic jaundice, pernicious anemia and thrombopenia purpura hemorrhagica. As Doctor Brenizer has brought out hemolytic jaundice is the one condition where splenectomy does most good. In other conditions such as in purpura hemorrhagica, where there is a tendency to remissions, splenectomy is not always indicated. I think there is another reason for renewed interest in the study of splenic surgery, namely, the effect splenectomy has on the organism as a whole. That question has especially interested me particularly in solitary cysts, where the whole spleen has been destroyed. In solitary cyst of the spleen the whole thing is destroyed and the cysts gradually become larger and larger. What happens to that individual after splenectomy? I have

had only two cases. One was a girl, age 20, in good health ordinarily, rather robust. She began to lose weight and develop acne over the face, and the mucous membranes became pale, evidently a lack of vitamin A. After the spleen was removed the acne cleared up and she had no more digestive disturbances, yet she looked older, and the mucous membranes remained pale. What has the loss of the spleen done to this patient?

DR F B LUND (Boston, Mass.) I know nothing about the spleen, but there was a tradition in ancient times that the spleen was removed from men who were going into training for foot races and was removed on account of its weight. I do not believe that was done and can find nothing about it in ancient literature. I believe that if the ancients did remove the spleen their patients never ran again. However, they did know about the relation of the spleen to the liver. They constantly felt the enlarged spleen. One finding was described by Hippocrates. Plato, who was not a doctor but a man with a tremendously active mind, speculated about the function of the spleen, and he decided that when the liver was diseased the spleen absorbed the poisons taken from the liver and swelled, and when the liver got better the swelling in the spleen went down. It is a curious thing that although Plato probably did more to retard medicine than anyone else, in this he set forth a principle that we are still trying to explain 2,000 years later. Malaria is very prevalent in Greece now and I want to call your attention to what an American philanthropist has done for Greece. If you go to Marathon (where the fight was) you will find a small tablet in honor of the great philanthropist "Rocfelai" (John D. Rockefeller), who drained the marshes at Marathon and thus kept down malaria. There is a clinic there conducted by the Red Cross. I was there five years ago, I never saw so many spleens in my life. Three years later, I visited it again and saw hardly a spleen. There is hardly any malaria because of education and teaching the natives to fight mosquitoes and use screens. So that is what one American has done to eliminate malaria and enlarged spleens in Greece. The spleen was thought to be the organ that eliminated the black bile from the system, and the word melancholia originates from that belief. For that reason disagreeable and irritable people are said to be 'spleeny'.

DR LUCIUS E. BURCH (Nashville, Tenn.) I merely want to call the attention of the Association to an incision brought out by our president, Doctor Singleton, in an original article, and also in an editorial in Surgery, Gynecology and Obstetrics. This incision offers an easy access to the upper abdomen. It is planned along anatomic lines, and does not interfere with important nerve supply to the part, it also has the great advantage that it is easy to close.

DR ADDISON G. BRENIZER (Charlotte, N. C., in closing) Any paper I have ever presented before this Association I have presented with the idea that I would learn something from the discussion it might arouse. Of course I have not the slightest idea about why the usual elliptic red cells should become spherical before they become deglobulized. I do know merely that the red blood cells of the patient become spherical and believe that the cells from a donor also become spherical. I cannot answer that positively. I hope I can find out. I think it is likely that I shall never perform another operation, but I shall always come back here to get information and some ideas exchanged. I never give any instruction because I have little to give, but I obtain an enormous amount of knowledge from you all. Like looking at the mountains in North Carolina, if I thought it were to be my last look at them or you, I should, indeed, be overwhelmingly saddened at the thought.

FURTHER EXPERIENCES IN CONSTRUCTION OF THE VAGINA[†]

REPORT OF TWELVE CASES

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TWO YEARS ago, before this society, I¹ described a new and simple method of constructing the vagina. The present communication is merely a summary of the experience of those who have employed this operation.

In all, six surgeons have communicated with the author and have performed the operation, more or less according to the suggested technic. Including three cases operated upon personally, a total of 12 vaginal constructions have been performed by seven different surgeons. Follow-up examinations have been obtained in 11 of these 12 cases.

It might be well to recapitulate the technic of the operation. The principle of this operation was

new, as it depended upon the proliferative capacity of the squamous epithelium of the vaginal introitus to spread and cover the walls of the newly created vaginal space.

The operation attempts to reproduce the situation which exists in the fetus, in which the squamous epithelium of the external genital surface (the urogenital



FIG. 1.—The vaginal mold. This measures 10x4 cm. and is made of balsa wood. It is well to have molds of various sizes to fit the dissected space. The mold can be made of any rigid light material. To make it nonabsorbent, sterilizable and prevent it from sticking to the raw surfaces, it should be covered with rubber (a condom will serve). Electroplating with silver makes an excellent mold. (ANNALS OF SURGERY 107 No. 5, p. 844, Fig. 1, May, 1938.)

sinus) grows up toward the müllerian ducts and, with the müllerian ducts, thus forms the vagina. I had performed this operation first in 1928.

The technic of the operation is quite simple. The vaginal space is dissected, as usual, between the rectum and bladder. That concludes the operative procedure. No foreign tissue is introduced. Pinch-grafts of labial epithelium may be used but are not necessary. Into this space is fitted a smooth vaginal form made of some light, fairly rigid material, which will not adhere to the raw vaginal walls. The author has used a number of substances, but, recently, has favored a mold of appropriate size made of balsa wood and covered by a rubber condom. Such a form can be made anywhere and can be given

[†] Presented before the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

to the patient to use when she goes home (Fig 1) This form is placed in the vaginal space at operation and left undisturbed for three weeks, after which it is removed, cleaned and replaced After this, the patient makes occasional visits to the doctor's office, where he can remove the form, observe the progress of epithelization and keep the wound clean No antiseptics are applied which can injure young epithelium The form is then worn most of the time for the next month, and after that at night for another period of three weeks, or until the vagina is completely covered by epithelium Intercourse



FIG 2—Case 1 Dr John Burch, Nashville, Tenn A photograph showing the result, nine months after operation (ANNALS OF SURGERY, 107 No 5, 852, Fig 5, May, 1938)

is forbidden until the space is well epithelized, which may take two to four months, at least until the mucous membrane is thick and strong

Employing this technic, one merely dissects out the required space for the vagina, keeps it open and allows the squamous epithelium from the vaginal introitus to grow up and cover the walls of this space

ABBREVIATED CASE REPORTS

Cases 1 and 2—Dr John Burch, Nashville, Tenn The first case was a white girl, age 18, who had cramps in the lower abdomen every month, but had never menstruated The vagina was absent In September, 1936, a vaginal canal was dissected and packed with loose gauze An infection developed on the fifth day, the gauze packs were removed, and a vaginal mold covered by a rubber condom was placed Two days later this was expelled, the space was irrigated and the mold replaced This was then kept in place till the twenty-second day The patient was discharged on the thirty-second day

Follow-Up—Nine months later Examination showed the vagina to be large, and admitted a full size vaginal speculum, it was 8 to 10 cm deep The end-result is shown

in Figures 2 and 3 Figure 2 is a photograph of the vaginal orifice, nine months after the operation Figure 3 shows the size of the vagina, as it admits a full size vaginal speculum The result in this case was excellent The author's technic was not followed in the beginning, as the vagina was packed with gauze instead of being kept open with a smooth vaginal form After the gauze was removed and a suitable form used, the convalescence was normal

Case 2—Dr John Burch, Nashville, Tenn A white girl, age 17, recently married, with absence of vagina In July, 1939, a vagina was constructed, using author's technic The convalescence was normal till after removal of vaginal form on the fourteenth day, when there was some bleeding On the twenty-fifth postoperative day, there was an



FIG. 3.—Case 1. Dr John Burch, Nashville, Tenn The depth of the vagina nine months after operation A full size speculum is easily introduced The vagina is 9 cm deep (ANNALS OF SURGERY 107, No 5 852, FIG. 6 May 1938)

alarming hemorrhage, about 500 cc, from an artery in the right vaginal wall This was ligated Transfusions were given The later convalescence was uneventful

Follow-Up—Three months later, October, 1939 The vagina had healed except for some granulation tissue in the vault of the newly formed vagina No discharge The vagina is 12 cm deep, and easily admits two fingers Figure 4 is a vaginogram, three months after operation, showing the vagina distended by a condom full of barium The constriction ring in the condom is not evident on inspecting the vagina It probably is due to incomplete filling of the condom Biopsy showed squamous epithelium

Case 3—Dr Nathan P Sears, Syracuse, N Y A girl, age 22, engaged to be married Diagnosis Absence of vagina Seven months previously, an effort had been made to construct a vagina, employing Thiersch grafts The result was a failure There was only a narrow tortuous sinus, 3 or 4 Mm in diameter, where the vagina should be

Seven months after this operation, the patient consulted Doctor Sears, who performed the first stages of a Frank-Geist operation He made the usual "satchel-handle" flaps of skin from the thigh

About three weeks later, the vaginal space was dissected Because of dense adhesions and the scar caused by the first attempt to make the vagina, this dissection took two

CONSTRUCTION OF VAGINA

hours and 40 minutes One week later, the tubular graft was inserted into this space, around a vaginal mold Two weeks later, when the vaginal mold was removed, most of the graft came with it One week after this, the vagina was inspected, and epithelium was observed growing at the outer end A glass form was fitted, which the patient wore continuously for several months, after which it was inserted for only an hour or so daily

Follow-Up—Three years later The vagina was perfectly formed, 10 cm deep, lined with soft, epithelial-like covering The patient had been married one year, and enjoyed perfectly satisfactory sex relations Biopsy and vaginogram not taken

Final Result—Excellent In this case, as Doctor Seats says, although he employed my technic "more or less by accident, the result was perfect" This case brings out, in a very striking manner, the complicated steps in the other methods of making a vagina,



FIG 4—Case 2 Dr John Burch, Nashville Tenn Vaginogram, taken by distending the vagina with a condom containing barium The vagina is 12 cm deep, easily admits two fingers It is lined by squamous epithelium (biopsy) The hour glass appearance is due to incomplete filling of the condom and is not appreciable on vaginal examination

as contrasted with the simplicity of the author's technic The time element is also clearly contrasted, for this young woman spent 48 days in the hospital, during which time she had three rather long and complicated operative procedures, in performing the first steps of the "satchel-handle" tubular flap operation After she was fitted with the vaginal form, she went home in one week

Cases 4, 5 and 6—Dr Buford Word, Birmingham, Ala

Case 4—The unusual feature in this case was the association of a horseshoe kidney Vaginal construction December 9, 1937 Married February 26, 1938 Last report October, 1939, saying that patient is happily married and that her sexual life is "pleasant and satisfactory"

Case 5—Colored, age 20, married Normal female, except for absence of vagina and uterus Vaginal construction November 25, 1938 Discharged from hospital on fifth day Convalescence normal Result, excellent Coitus normal, with orgasm Biopsy, ten months after operation, shows vagina lined by squamous epithelium

Case 6—White, age 20 Complaint, amenorrhea The patient had been receiving endocrine therapy hypodermically to make her menstruate, gynecologic examination made after a year or more of this therapy showed complete absence of vagina and uterus Vagina constructed, May, 1939 Result, excellent Biopsy, September, 1939, showed squamous epithelium The vagina is well formed and commodious As this young woman expects to be married in December, 1939, the final reports are not yet available

Case 7—Dr A A Skemp, La Crosse, Wis Date of operation, August, 1938 Doctor Skemp had made two former efforts to construct a vagina in this case, but both efforts had failed At the first operation, he had packed the vaginal space with gauze, this was followed by a small fistula which communicated with the rectum

This patient complained not only of the gynecologic defect but also of bladder symptoms—chiefly blood in the urine Apparently, the *urethra* had been tremendously dilated



FIG 5—Case 9 Dr I R Wharton A vaginogram taken 1 year after construction of vagina The vagina is large and measures 9 cm deep Sexual intercourse normal, with orgasm (ANNALS OF SURGERY, 107, No 5, 550 Fig 3, May 1938)

by coitus and it admitted two fingers This proved to be advantageous to the surgeon, for he could orient himself during the vaginal dissection by keeping one finger in the urethra

The last operation, performed in August, 1938, employing the author's technic, gave an excellent result

Follow-Up—October, 1939, 14 months postoperatively The vagina was 11 cm deep, distensible and painless The patient was "completely satisfied with the results"

Cases 8, 9 and 10—Dr L R Wharton

Case 8—A pseudohermaphrodite, white, age 26, who wanted to be married Operation 1928 This case was reported in detail in the ANNALS OF SURGERY, 107, No 5, 842-854, May, 1938 The immediate result was perfect The ultimate result is uncertain In reply to our letters, the patient expresses herself as well satisfied, nine years

later She fails to describe the situation in detail, and, since she lives 600 miles from Baltimore, a follow-up examination has not been made Result Unknown This was the first patient to be operated upon, utilizing the new technic I did not report this case earlier because I did not know the end-result

Case 9—A married woman, age 30 This case was reported in *ANNALS OF SURGERY*, 107, No 5, 842-854, May, 1938 The final result was excellent, except that the patient had a tiny vesicovaginal fistula, which was hardly visible and leaked only a few drops occasionally The vagina, two years after operation, was 9 cm deep, and was commodious (Fig 5) The figure is a vaginogram, the constructed vagina being filled with a condom containing barium The character of tissue lining this vagina is shown in Figure 6, this biopsy having been taken from the apex of the constructed vagina, one year after the last operation

This case was complicated by the lack of co-operation of the patient After the first operation, she demanded that the vaginal form be removed because she feared it would injure the rectum, this nullified, to an extent, the first operation One year later, the second operation was performed In spite of our warnings, she promptly had sexual intercourse immediately after leaving the hospital, three weeks after the operation This stripped off some of the young epithelium and left her with a vagina about 7 cm deep One year later, the final operation was performed, securing a vagina which was 9 cm deep (Fig 5) At this last operation, however, the dense scar tissue made the dissection very difficult, and a small hole was made in the bladder This was closed, a retention catheter placed and the convalescence was normal There is still a tiny vesico-vaginal fistula, which is so small that it does not drain enough to make the patient wish to have it closed Result of vaginal construction Good

Case 10—A young woman, age 21, who desired to be married The only abnormality was the absence of the vagina and uterus This young woman had had two former operative attempts to form a vagina, each time the vagina being packed with gauze As soon as the gauze was removed, the cavity collapsed

Examination showed a shallow vagina about 3 cm deep Operation May, 1939 The patient was kept in the hospital three weeks, and then allowed to go to her home in Alabama, to have the necessary postoperative care under the supervision of her family physician She apparently developed an irritation of the vaginal orifice, and the insertion of the form became very painful She consequently neglected to wear the form, and the cavity collapsed, adhered, and finally became only 5 cm deep When she left the hospital, it was 13 cm deep, and unusually commodious Her physician had advised her to return to Baltimore as soon as she found it difficult to insert the form She refused to do this, however, and gradually lost the benefit of the operation

In October, 1939, she returned, requesting that the vaginal operation be repeated The difficulty and risk of the operation was explained, as this would be the fourth dissection of the rectovesical septum Nevertheless, she demanded that the effort be made At operation, however, there was no plane of cleavage, dense scar tissue bound the mucous membrane of the bladder to the rectal wall After the space had been dissected to a depth of 7 cm, a hole was accidentally made in the bladder This was immediately closed and the bladder drained by a urethral retention catheter Further attempt to



FIG 6—Case 9 Dr L R Wharton Biopsy of vaginal wall one year after construction, shows a lining of normal vaginal epithelium (Union Memorial Hospital Path No 10 276) (*ANNALS OF SURGERY* 107 No 5 851 Fig 4, May 1938)

enlarge the vagina was abandoned. The final result was that this girl now has a vagina about 5 or 6 cm deep, about half as deep as it was after the author's first operation. In this case, the benefit of the operation had been largely lost by the failure of the patient in neglecting the proper postoperative care. Also, this case again emphasized the extreme difficulty that attends third or fourth attempts to dissect out the space for the vagina.

Case 11—Dr J. Mason Hundley, Jr., Baltimore, Md. This case was published in the *ANNALS OF SURGERY*, 107, 842-854, May, 1938.

The patient was a pseudohermaphrodite, white, age 26. Testes were the only gonads, the external genitalia were of the female type, the testes were in the groins. There was no vagina. Since the patient had been raised as a girl, she wished to have a vagina so that she might marry.

Vaginal construction and an exploratory celiotomy were performed, November 10, 1937. Six days before this operation, the operator had partly dissected the space between the rectum and bladder, but had done nothing else. It happened that the author read his preliminary report of his method of constructing the vagina at a medical meeting and Doctor Hundley utilized the technic on this patient. The immediate result of the operation was successful. The patient discontinued the use of the balsa wood forms, however, and the space contracted. She, therefore, consulted a surgeon elsewhere, who stretched the vagina and covered the raw surface with Thiersch grafts. The result was apparently excellent. The patient is now married. We consider the first operation a failure, due to the failure to follow the proper postoperative care.

Case 12—Dr Charles Stevenson, Baltimore, Md. This patient was a colored girl, about 15 years old, whose only complaint was the inability to have intercourse. The only demonstrable physical defect was the absence of a vagina and uterus. Operation, May, 1939. The surgeon reported that the operation was easy and completed without difficulty. The hospital convalescence was also satisfactory. There was some difficulty in the late postoperative care, however, and the vaginal forms were not used. The vagina was apparently about 4 cm deep when the last examination was made. This operation is therefore classed as a failure.

Genito-Urinary Malformations Associated with Absence of Vagina—This phase of the problem is not within the realm of this paper, therefore, it will be dismissed by merely summarizing the findings. In a forthcoming study, this interesting question, and the findings in these and other cases, will be presented in detail.

In these 12 cases, ten were normal females, as far as sexual differentiation was concerned. They presented no trace of hermaphroditism. Two were pseudohermaphrodites, of the male sex, with female secondary sexual features and female external genitalia. These two pseudohermaphrodites had testes, and no ovaries. They had no visible müllerian duct.

In one of the 12 cases, there was a horseshoe kidney. In a future study, we shall present a case that had complete absence of one kidney with incomplete descent of a functionless, cystic ovary, another case showing absence of one ovary, and a third, with myomata, as large as a grapefruit, developing from a uterus no larger than a thumb.

In general, every case of absence of the vagina should have a complete genito-urinary examination because of the possible association of other malformations.

Discussion—Final Results The author has assembled a group of 12 operations for constructing the vagina according to the suggested technic. These

operations were performed by seven operators. The final results of the operation were perfect in eight cases, unknown in one case, and complete or partial failures in three cases. In the successful cases, the constructed vaginas were lined by squamous epithelium in every case in which a late biopsy was taken. The vagina was usually 9 to 13 cm deep, commodious and insensitive. Some of the patients expressed themselves as being completely satisfied, sexual life was normal, orgasm was definitely experienced by some of these women. In one instance, the author observed that the vagina increased in depth by 1 cm during the first year after operation, showing that the vagina is pliable.

Operative Difficulties—The rectovesical septum is normally soft and presents a clean plane of cleavage. In the absence of scar tissue the rectum and vagina can often be separated by blunt dissection in a very few minutes. This step is common to all operations for constructing the vagina.

If this septum has been repeatedly mutilated, infected and scarred-over by previous dissections, it is gradually replaced by dense fibrous tissue, which binds the very delicate bladder mucous membrane and muscle to the thicker rectal wall. Hence if one is unfortunate enough to have to try to make a vagina after two or three others have failed, he is sure to experience great difficulty in dissecting the space between the rectum and bladder. The chances are even that he will injure the bladder; in one case, a surgeon injured the rectum. One can orient himself by keeping a sound in the bladder and an assistant's finger in the rectum. In spite of this, however, the bladder will be unavoidably perforated occasionally. This emphasizes the importance of refraining from ill-advised attempts to make a vagina, a failure will only lessen the chance of future success and greatly increase the probability of vesicovaginal or rectovaginal fistula.

The Type of Vaginal Form—In these operations, various substances have been used to construct a vaginal mold or form, such as large rubber tubing covered with layers of gauze, tongue depressor wrapped with gauze, melted paraffin poured into a condom, balsa wood molds, and molds made of the obturator of a proctoscope, plated with silver. All of these substances, with the exception of the silver form, have been covered with thin rubber (condom) to keep them from sticking to the raw vaginal walls. All of these forms have been satisfactory. It seems that the only essential features are that the form should be sufficiently rigid to resist the constant pressure of the perineal muscles, smooth, so that it will not adhere to the sides of the vagina, clean and sterilizable, nonabsorbent, so that it will allow good drainage, and light, so that it will not press on the rectum. The silver form made by Doctor Wood is probably the most satisfactory, but cannot be made by everyone, and cannot be given to the patient. The simpler forms have, however, proven just as satisfactory, although we would prefer the silver form when available.

Use of Mucous Membrane Grafts—These have not been necessary, as shown by the successes obtained when they were not employed. The author used them in his last case, but did not notice any increase in the rate of epithelization. It is possible that they may act as foreign bodies and predispose

toward infection if they do not "take" We see no objection against placing a few pinch-grafts over the end of the vaginal form, cutting these grafts from the inner surface of the labia minora But this step is not necessary, if the vaginal space is cared for properly and kept open, the result will be good in either case

Necessity of Retention Catheter —We have used a retention catheter only when the bladder has been injured An indwelling catheter has been used by about half of the operators If it is not used, it may be necessary to catheterize the patient once or twice, but after that urination is usually normal In one instance, the retention catheter increased the pressure on the vaginal mold sufficiently to pinch the urethral meatus and cause a slough in the urethral wall just under the pubis, at the external orifice This did no functional damage, it is however, unnecessary

Length of Hospitalization —Some operators have allowed their patients to go home in five days, others eight or nine days, still others after three weeks The results have been equally good in all cases

Postoperative Care —Most operators have not removed the form till the twenty-first or twenty-eighth day It is easily removed and replaced, without anesthesia The vaginal walls can then be examined most readily in the knee-chest position and the process of epithelization watched

The after-treatment consists in keeping this space open and clean One may irrigate it occasionally, using salt solution or boric acid Weak antiseptics such as mercuriochrome (2 per cent) can be applied The lubricated form must be worn most of the time for two months As the walls become more rigid and covered with the blue layer of thin epithelium, the form can be left out part of the time Eventually, it can be left out permanently, after the epithelium has become thickened

Intercourse is prohibited till the epithelium is thick and strong This will probably take three months, although in one case (Wood) the patient married ten weeks after the operation and has had normal sexual relations ever since

Bleeding —Hemorrhage was a serious complication in one of these 12 cases It is imperative that the vaginal walls be completely dry before the form is introduced The points from which one may expect serious bleeding are on the lateral walls, in the position of the broad ligaments These areas are vascular and may require transfixion sutures If the walls of the space are not dry, the seepage of blood may force the form out, in one case, the post-operative hemorrhage was enough to require transfusion

Infection —This has not been a factor in any case in which the author's technic was employed Careful technic in the operating room, hemostasis and lack of trauma help to avoid infection

THE CAUSES OF FAILURE AND COMPLICATIONS

(1) *Failure to wear the vaginal form* It is essential that the space be kept open All of our failures are definitely traced to the patient's neglect in wearing the form

(2) *Injury to bladder or rectum* The surgeon who is the first to separate the rectum from the bladder has an easy task, he can do the operation by blunt dissection in a few minutes. The surgeon who performs the second dissection a year or so later has a definitely harder task, as there is a good deal of scar tissue. If he fails to make a satisfactory vagina, the next operator runs an even chance of injuring the bladder or rectum. The fourth trial is almost sure to be futile.

If the bladder is injured, it is immediately closed over, using whatever tissue is available. If there is any solid vaginal mucosa, it is a great asset. One cannot very well enlarge the vagina after the bladder has been torn. Also, it may be risky to use a vaginal form, although in one case the author did place a form and got an excellent result. The patient still has a small fistula, however, just enough to leak a few drops intermittently. Injury to the bladder or rectum immediately lessens the chance of making a satisfactory vagina.

It is to be remembered that the dissection of the vaginal space is a necessary step in any operative method of making a vagina, and that the above statements would, therefore, apply equally to any surgical method of constructing the vagina. The only method of constructing a vagina which does not involve any surgical dissection is the gradual dilatation of the vaginal space by manual pressure, using a glass or metal dilator. This is probably one of the oldest procedures, having been described and practiced about 100 years ago, it has recently been reintroduced.

CONCLUSIONS

The author's method of constructing the vagina has been employed by six other surgeons. In all, 12 cases have been operated upon.

The final results have been perfect in eight cases, partial or complete failure in three, and unknown in one.

The depth of the vagina, as determined by follow-up examinations, several months to three years after the operation, has varied from 9 to 13 cm. in the eight successful cases. It has been commodious, insensitive and distensible.

The vagina has been lined by squamous epithelium. It is our opinion that this grows up from the epithelium at the vaginal orifice.

The length of hospitalization varies from five days to four weeks.

Postoperative hemorrhage was encountered in one case.

Sexual relations have been described as satisfactory to both husband and wife.

Operative injury to the bladder or rectum occurs occasionally, in 12 cases, the rectum was injured once, the bladder twice. In patients who have been operated upon several times, the rectovesical septum is a mass of scar tissue and injury to these hollow viscera may be unavoidable. One should hesitate before attempting to operate upon a person for the third time and explain the situation to the patient, at a fourth operation, the chance of injuring the bladder is very great, and the likelihood of forming a satisfactory vagina equally slight. Gradual dilatation of a small, shallow vagina, 5 or 6 cm.

deep, may make it considerably deeper, provided there is not too much scar tissue

If the vaginal space can be dissected satisfactorily, one can almost guarantee a good result if the vaginal cavity is kept open and clear. This emphasizes the importance of operating only upon women who will cooperate in carrying out the proper postoperative treatment.

In conclusion, the above record shows that six surgeons, who had never seen the operation performed, carried out the technic and obtained good results. In 12 cases, there were eight successes, and three partial or complete failures. There were no deaths.

REFERENCES

- ¹ Wharton, Lawrence R. A Simple Method of Constructing a Vagina. *ANNALS OF SURGERY*, 107, No. 5, 842-854, May, 1938.
- Woid, Buford. Report of cases to be published in *The Southern Medical Journal*.

CONGENITAL ARTERIOVENOUS ANGIOMA OF THE ARM*

METASTASES ELEVEN YEARS AFTER AMPUTATION

RUDOLPH MATAS, M D

NEW ORLEANS, LA

THIS is the history of a patient with a congenital arteriovenous angioma (cavernous type) of the right upper extremity, complicated by grave cardiovascular disturbances, regional recurrence and seeming metastases in the corresponding right axillary scar and chest wall, *eleven* years after disarticulation of the arm at the shoulder, excision of the chief metastatic growth in the axillary scar and chest wall, with recovery and seeming freedom from recurrence or metastasis almost four years later †

The patient evidenced an arteriovenous angioma of the cavernous type which, appearing externally at birth as a small pulsating swelling in the little finger of the right hand of a congenitally hypertrophied arm, grew upward until, in the course of 21 years, it reached the armpit. Its advance was first checked temporarily, when the patient was 16 years old, by an amputation of the forearm, after the ligation of the radial and ulnar arteries had failed to control it. Recurrence soon followed in the stump, compelling the amputation of the arm at the shoulder at the age of 21.

The case owes its chief interest to the fact that *nearly 11 years* after the amputation at the shoulder, and after the apparently complete recovery of the patient, the disease recurred as a regional metastasis in the axilla and scar of the amputation and as a separate angioma at a distance, in the corresponding side of the chest wall. The clinical characteristics and the microscopic examination of the new growths fully confirmed their histologic and clinical identity with the primary angioma of the arm amputated 11 years before. This tumor, therefore, enters that very rare group of the *metastasizing hemangiomata* which are at present claiming much of the attention of pathologists and clinicians in an endeavor to account for the seeming paradox of a histologically benign and clinically malignant tumor. In other words, a histopathologic illustration of the old fable of the "wolf disguised in sheep's clothes."

Another distinctive feature of this growth, and quite apart from its purely oncologic or tumoral aspect, is the effect that the growth, as an arteriovenous cavernoma, has had on the heart and circulation in the course of its long developmental history. When we realize what a single arteriovenous fistula

* Read before the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

† A preliminary report of this case in abstract was read at the meeting of the Southern Surgical Association at Biloxi, Miss. (December 16, 1936), but delayed for publication to permit of further observation in regard to recurrence and metastasis. An interval of nearly four years has elapsed since the performance of the last operation (April 8, 1936) and at the present date (January 20, 1940), the patient is in good health and, apparently, without signs of recurrence or metastases.

between a large artery and vein can do to injure and cripple the heart, we can understand how a monstrous tumor like this, which is structurally but a coarse sieve through which the arterial blood of the whole extremity is poured directly into open venous channels without the interposition of the capillary bed—must strain the heart by the enormous venous overflow that is shunted into it through the open arteriovenous channels in the tumor. The remarkable recovery of the heart and circulation after the amputation of the arm, despite the many years that the patient had been disabled by his abnormal circulation, and the new therapeutic and prognostic problems set up by the unexpected reappearance of the growth, in connection with the intrinsic interest that attaches to this rare and formidable type of vascular growth, would seem to justify the detail with which the history is herewith presented.

Case Report—When the patient, C. C., male, age 21, first came under my care, February 20, 1925, he appeared as a rather undersized but well-proportioned youth of Israelite-American descent, five feet four inches in height, weighing about 130 pounds. He was an alert student, who had advanced at college despite the handicap of a disabled right arm and long suffering caused by the angiomatous disease. His family antecedents were excellent. There was, apparently, no sign of hereditary disease or deformity in his immediate and remote ancestry and collaterals, the father was living, normal, and without complaint, at age 58, and his mother likewise well, at age 47. He was the youngest of three children—a brother and sister, both healthy, vigorous and without complaint.

His mother stated that at birth he was, in every respect, a perfectly normal baby except for a notably enlarged right arm, including the hand and forearm, both in length and circumference, and although differing from the opposite arm in size, it was in no way large enough to attract attention as a deformity. The enlargement suggested a simple hypertrophy without deformity or edema. The enlargement seemed to involve all the parts symmetrically, even the bones feeling larger and thicker than on the other side. There was no difference in the use of the arm. Apart from this uniform enlargement, the only feature to attract attention was a small red birthmark (nevus) on the little finger of the right hand.

Although physicians were consulted, nothing was done therapeutically as there was little or no functional disability, though the limb continued to enlarge very gradually with the growth of the child. Otherwise, the baby grew and developed as any other healthy, normal child, giving no cause for anxiety until he was three years old, when he was seized with an acute metapneumonic empyema from which he had a narrow escape only after the resection of a rib and long pleural drainage.

This operation and a tonsillectomy, at age six, constituted the chief complications that were added to the patient's slowly enlarging arm, until he was 11 years old, when he began to suffer irregularly from periodic attacks of pain with extreme sensibility of the hand, wrist and fingers, accompanied by some fever. These episodes were so severe that they kept him in bed while they lasted, usually for several days, and a notable increase in the size of the arm followed each attack. These attacks were renewed at long intervals until he was 14 years old when he was prostrated by an extraordinarily violent illness limited to the affected arm. It was diagnosed acute articular rheumatism, which kept him in bed for over seven weeks. This attack involved all the joints of the fingers, hand and wrist and, judging by the description, had all the characteristics of an acute arthrosynovitis with fever and an exquisite pain on touch and motion that caused unutterable suffering. When the attack finally subsided, the hand was left permanently swollen and disabled, with all the joints of the hand and wrist thickened, stiff and disfigured by hard edematous swelling.

The true nature of these attacks is not known nor their relation to the angiomatous disease which, though unrecognized at the time, had undoubtedly existed in the hand since birth, but the periodicity of these attacks, the unilateral, regional localization, with fever and progressive swelling after each attack, are suggestive of the periodicity of elephantiasic fever and permanent lymphedema caused by Unna's streptococcus of elephantiasis nostras.

The permanent swelling, stiffness and pain in the hand, which completely disabled the arm, led the parents to take the patient to the Mayo Clinic. This was in 1919, when he was 16 years old, and where the first serious study of his case was undertaken by Dr J deJ Pemberton, who recognized the angiomatous disease which had been at the bottom of the boy's pathology since birth.

I am very much indebted to Doctor Pemberton¹ for directing my attention to a summary of this patient's case while at the Mayo Clinic, in a very valuable paper on "Congenital Arteriovenous Communications," prepared by himself in conjunction with Dr James H Saint, which was published three years after I had operated upon the patient in New Orleans. The observations are very valuable, as they provide the essential data regarding the condition of the patient and his tumor at a most important period of



FIG 1—C C age 15 Congenital cavernous angioma (arteriovenous) of hand wrist and forearm. Reproduced by courtesy of Dr J deJ Pemberton from photograph taken at Mayo Clinic in 1919 (Pemberton and Saint Surg Gynec and Obstet, 46, 472, April 1928)

his history, besides, they afford an excellent photograph of the hand and forearm before the progress of the disease compelled their amputation (Fig 1)

Quoting the description given by Doctor Pemberton,¹ in his paper of 1928, we learn that "The patient, C C, was first admitted to the Mayo Clinic in 1919 when the right arm was seen to be of greater girth than the left, also exceeding it in length by 1.25 cm. A pronounced arteriovenous bruit was heard in the palm of the hand and in the right clavicular region. Roentgenograms of the hand showed what seemed to be a destructive arthritis of the proximal ends of the metacarpal bones and bones of the carpus. The radial and ulnar arteries were ligated at different intervals and divided (Doctors Henderson and Myerding). At these operations all the vessels in the neighborhood of the wound seemed to be enlarged. Following these ligations the size of the hand was reduced one third, and the bruit and pulsations were considerably diminished." It was now evident, also, that the great bulk of the swelling in the hand and fingers was caused by the steadily growing angioma.

The patient again visited the Clinic in 1920. Six months previously, he had noticed a dark scab over the joint of his little finger, at the seat of the primary birthmark or nevus. One month prior to his arrival at the Clinic the scab broke down and a very painful, progressive ulceration followed. It was then decided that an amputation through the middle of the forearm was necessary and this was performed (Doctor Henderson) in September, 1920 on the eve of the patient's seventeenth birthday. The pathologist's report was "progressive gangrene of the fingers and half of the hand with the beginning of ulceration on the dorsal surface of the little finger." (The precise cause of the gangrene is not stated.) The amputation gave the patient great relief and made him free to enjoy outdoor sports especially one arm tennis, which his sensitive and long suffering right hand had previously denied him.

Three years after this event (1923) the patient (then a student at Washington University), while going through a periodic physical examination, was told by the medical examiner that he had an

aneurysm in the subclavian region which was seriously affecting his heart. He was then advised to return to the Mayo Clinic, where he was readmitted in July or August, 1924. There he was examined by Doctors Pemberton and Henderson, and the late Doctor Brown whose attention was chiefly directed to the right supraclavicular region, where all the signs pointed to a congenital arteriovenous aneurysm of the subclavian vessels.

Again quoting the observations of Doctors Pemberton and Saint: "A systolic pulsation was visible in the supra and infraclavicular areas and a subdued thrill which was best obtainable in the right supraclavicular space. The stump of the right forearm, which had been amputated three years previously, was about three times larger than the normal side, tapering off toward the shoulder. The whole arm pulsated with each systole. A loud continued bruit with systolic exacerbations, could be heard throughout the right arm and up to the clavicular region but it was most marked in the supraclavicular space. The superficial veins of the right arm were dilated to three or four times their normal size. The heart was markedly enlarged the apex heart being visible in the sixth left interspace. The systolic blood pressure in the normal left arm was 117/56, pulse 72." In a recent (January 5, 1937) personal letter, Doctor Pemberton states that one interesting feature of the examination which was not included in the case report of 1928 was "a marked difference in the blood pressure of the right and left arms, that in the right arm being 130/85 while that in the left was 106/56." Continuing with the notes recorded in 1924: "The surface temperature of the right arm was 96.4° F., while that of the left was 91° F. The blood in the veins of the right arm was examined for differential oxygen content by the late Dr. Brown who found the venous blood flowing from the arm to be almost arterial in character, as determined by the oxygen saturation (90 per cent for the right 30 per cent for the left arm). Dr. Brown also tried to visualize the arteriovenous fistula which was supposed to exist between the subclavian vessels with a sodium iodide radiopaque solution, but this failed to exhibit any arteriovenous communication, presumably because of the unusually free collateral circulation."

The conclusion arrived at at the Mayo Clinic was that the cardiovascular disturbance and angioma of the arm were dependent primarily on a congenital arteriovenous fistula of the subclavian vessels. No further operation or surgical treatment was advised for the time being at the Clinic, and the patient returned to Washington University, St. Louis, in September, 1924 and finished the prescribed four years' course in February 1925. Realizing that his condition was growing worse (enlargement of the arm stump, dyspnea, palpitation on exertion etc.), he came to New Orleans where I first examined him, February 20, 1925.



FIG 2—C. C., in 1925, age 21. Showing recurrence of the angioma in stump of forearm amputated four years previously. Note constricted club shaped stump, throbbing and purplish in dependent position. dotted lines indicate enormously dilated brachial vessels.

Physical Examination—Without any knowledge of the observations made at the Mayo Clinic, except the patient's statement that his case had been diagnosed as an angioma of the arm and arteriovenous aneurysm of the right subclavian vessels, my attention was immediately directed to the stump of the right forearm, which had been amputated four years previously. The appearance of the amputated limb, in comparison with the normal side, is well shown in Figure 2, which shows the club-shaped end of the stump and cylindric contour of the arm, gradually tapering toward the axilla.

AN ARTERIOVENOUS CAVERNOMA OF THE STUMP EXTENDS TO THE AXILLA
AS A PLEXIFORM ANGIOMA

The club-shaped end of the stump and larger size of the right arm ($5\frac{1}{2}$ cm greater at the elbow and 5 cm at the base of the forearm), the visible, heaving pulsation of the stump and of the whole arm up to its upper third with every beat of the pulse, the dark, congested, cyanotic color of the stump when allowed to hang down (Fig 2), with the marked reduction in size and pallor of the stump when the arm was elevated, were all signs which prepared the observer for the striking phenomena revealed by palpation and auscultation over the stump, namely, loud systolic murmurs blending with the venous hum, and the thrill which could be heard and felt vibrating under the hand from the terminus of the stump, especially in the neighborhood of the amputation scar, up to the upper third of the arm on the inner side, thence to the level of the axilla. On palpation, the brachial artery was felt to be enormously enlarged, growing larger as it approached the stump, where it was lost in the pulsating, heaving, humming stump of the forearm and above the elbow. The superficial veins of the arm also pulsated and were notably enlarged. The muscles of the forearm and lower third of the arm were incorporated, without anatomic differentiation, in one common mass of tense, pulsating, sponge-like tissue that could be grasped and emptied by a squeeze of the hand, giving the impression that the stump had been transformed into a tumor riddled with cavernous spaces through which the blood circulated in great volume. Even the lower end of the humerus, and the terminal distal stumps of the radius and ulna felt enlarged.

AN ARTERIOVENOUS FISTULA SIMULATED BY AN ENLARGED SUBCLAVIAN
ARTERY CLAMPED IN THE GRASP OF THE SCALENUS MUSCLES

Pursuing the investigation further up from the elbow to the axilla, and from the axilla to the supraclavicular triangle, the enlarged and vigorous pulsations of the brachial, axillary and subclavian arteries at once attracted attention by their prominence and vigor. Here again, the very large size of the subclavian artery, from its origin as it emerged from the innominate at the suprasternal notch, was most suggestive of an aneurysmal dilatation. Here again, all signs of an arteriovenous aneurysm which had developed in the amputated stump of the forearm were duplicated with even greater intensity. The systolic murmur could be heard above and below the clavicle and transmitted to the sternum as low as the third right costal cartilage, and with the superficial thrill which could be felt all along the subclavian tract but with greatest intensity about the crossing of the anterior scalene muscle.

All these signs pointed to an arteriovenous fistula which, seemingly, connected the subclavian artery and vein at about the crossing of the anterior scalene muscle. Against this view, however, was the fact that the enlargement of the artery did not end at the supposed seat of the arteriovenous fistula, but continued, enormously dilated throughout its course, down the arm to the elbow, where it was lost in the spongy mass of the cavernoma at the end of the stump, previously described.

The question that arose was whether the enlarged artery and dilated veins were sufficiently accounted for by the multiple arteriovenous communications in the cavernoma, or was there, in addition, an arteriovenous communication in the subclavian vessels as a part of the congenital vascular pathology of the extremity. Remembering that the enlargement of the artery on the proximal side of an arteriovenous fistula and the increased volume of arterial blood that flows through it is, teleologically speaking, but an effort to compensate for the relative ischemia of the tissues below the fistula, and that the enlargement of the artery is directly proportional to (1) The size of the fistula, (2) the volume of arterial blood that is short-circuited into the veins at the fistula, and (3) the duration of the fistula, and, since all these conditions were present and even enormously exaggerated in this case, I was inclined to attribute the enlargement of the whole arterial system of the upper extremity to the presence of the

cavernoma On the other hand, the murmurs and thrill in the upper supraclavicular region seemed to contradict this view in favor of the fistula I, therefore, decided that the only positive way to clear our doubts was to determine the presence or absence of the fistula by a thorough exposure of the subclavian vessels

Systemic Cardiovascular Signs and Symptoms—Before attempting an operation, however, it was decided that the cardiac and systemic cardiovascular changes that had been effected by short-circuiting of the arterial circulation in the cavernoma of the arm had to be carefully studied To this end, a series of teleroentgenograms showed that the *heart was enlarged in all its diameters* (Fig 3) Auscultation revealed the heart sounds to be of normal quality, accelerated but of regular rhythm, accompanied, however, by a

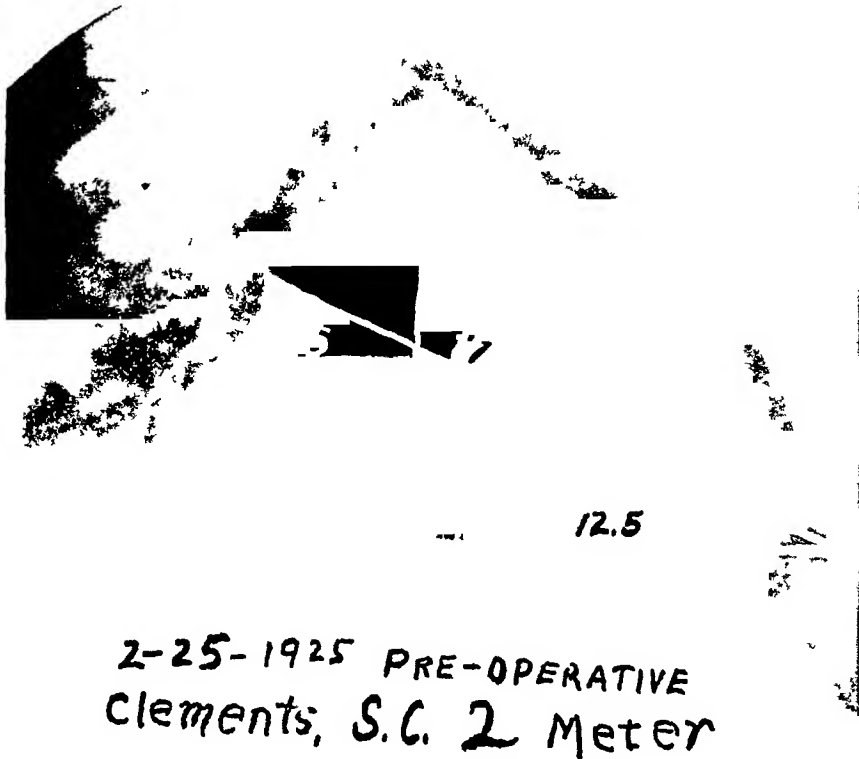


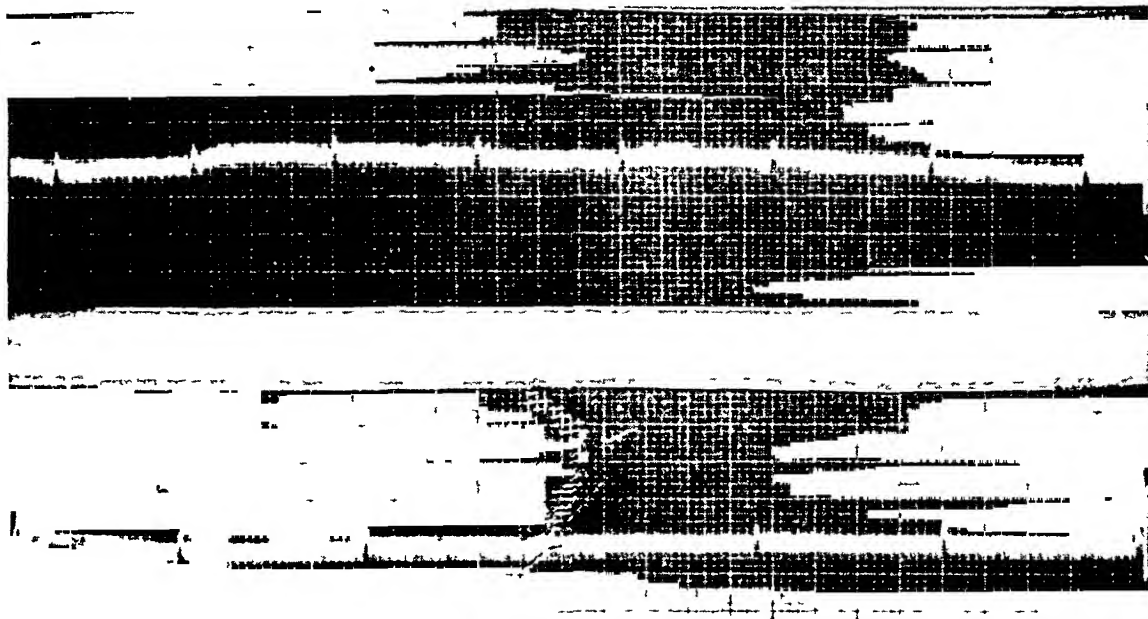
FIG 3—C. C., age 21. Preoperative teleroentgenogram of heart February 25 1925, before suppression of the angioma by amputation of the arm

loud systolic murmur which could be heard at the apex, which radiated up to the pulmonary area, and was heard loudest in that area Fluoroscopically, the cardiac shadow was seen to *contract* appreciably when (1) Firm digital pressure was put upon the subclavian artery, in the supraclavicular triangle, sufficiently to arrest pulsations and hush the sounds in the cavernoma of the arm, (2) the same result was obtained by encircling the arm with an elastic tourniquet or the sleeve of a sphygmomanometer, and (3) *when the spongy stump of the forearm was squeezed with a firm grip of both hands* Coincidentally with the contraction of the heart shadow, the pulse dropped from 80 to 70, and less, while the blood pressure in the left (normal) arm rose from 102 Mm to 130/72, which was also the pressure obtained in the angiomatous arm

The systemic effect of the angioma on the heart and circulation was more accurately and fully confirmed by Professor Garrey's studies of the patient in the Physiologic Laboratory of the Medical School of Tulane University, polygraph records and the electrocardiograms taken by Dr B Heminger in charge of the Heart Station at Touro (Graph 1) All these combined to demonstrate the arteriovenous structure of the

angioma and the characteristic effects of arteriovenous fistulae on the heart, the pulse rate and blood pressure—which I have collectively described as the “Branham syndrome,”²³ when they are manifested upon compression or obliteration of an arteriovenous fistula in traumatic arteriovenous aneurysms, and as the “Nicoladon⁴-Israel⁵ phenomenon” upon compression of an *arteriovenous angioma*, as in this case. All these signs and symptoms, so typical of the systemic effects of an arteriovenous fistula, made it necessary to intervene promptly in order to stop the arterial leak and the venous plethora that had already exercised a very damaging effect on the heart in this case.

Since compression of the third division of the subclavian artery reproduced the “Branham bradycardiac syndrome” with as much vividness as when the angiomatous stump was compressed by the hand or the cuff of the manometer, I decided to begin the attack on the angioma by exposing the subclavian tract and obliterating the fistula, if



GRAPH I—C C, age 21. Electrocardiogram, March 19, 1925 (Heart Station, Touro Infirmary, Dr. B. Heninger), showing effect of compression of the angiomatous arteriovenous stump. Average length of cycle 0.65 sec. Note the immediate slowing of the heart rate. This immediate slowing is at the expense of the diastolic period of the heart cycle (S-T interval). Average length of cycle after compression is 0.85 sec.

this was revealed. If no fistula existed, the artery would be ligated, in the hope that the ligation would check the growth of the angioma. To this end, the patient was admitted to the Touro Infirmary, April 2, 1925, and the operation was performed, April 3, 1925.

Operation—Preliminary control of the innominate artery for the exploration and search of a suspected arteriovenous fistula, with negative result. Ligation of the subclavian vessels.

Under local and regional (novocain-adrenalin) anesthesia, the innominate artery, greatly enlarged, was exposed as it rose out of the chest into the neck 1 ½ cm above the upper border of the sternum. The artery was as large as the normal abdominal aorta in its lower infrarenal course and was easily isolated and controlled by an elastic traction ligature (No. 1 soft rubber catheter) placed below the bifurcation of the innominate. Traction on this immediately reduced the size of the arm, stopped the thrill and silenced all the aneurysmal sounds in the neck and in the arm. A temporary ligature on the subclavian at the inner border of the scalenus anticus produced the same effect, showing that there was no arteriovenous fistula anywhere in the course of the subclavian artery, from its origin in the innominate to the crossing of the scalenus anticus. In addition, a very clean and bloodless dissection of the subclavian vessels, artery and vein conclusively demonstrated the total absence of any communication between the vessels, the

thrill and bruits being explained by the *constriction of the enormously enlarged subclavian artery* as it was held in the grip of the scalenus muscles. By dividing the anterior scalenus muscle, the artery was released from the constriction and the aneurysmal noises were silenced, even on relaxation of the ligature. When it was clearly demonstrated in this way that there was no fistula, the subclavian artery was definitely ligated outside of the anterior scalenus muscle, and the provisional traction loop on the innominate artery was removed. The corresponding subclavian and internal jugular veins, both very much dilated, were also ligated near their junction at the innominate bifurcation.

At the close of the operation, the blood pressure in the right arm was found to have dropped to 42 systolic and no definite diastolic. On the normal side the blood pressure was 110/68. The angiomatous arm, itself, appeared to have been the most benefited by the ligation. The stump at the forearm shrank and became noiseless and pulseless, while the pulse slowed and the general blood pressure rose. Cardiorenthgenograms, taken three days after the operation, seemed to show a reduction in the midright diameter of the heart.

Return of Pulsation and Relapse of the Angioma—The patient recovered without shock and the wound healed quickly, but, at the end of a week, the angiomatous stump began to pulsate and, in another week, the arteriovenous signs recurred in the arm, showing that the collateral circulation had been established. With the return of the arteriovenous short-circuit in the arm, the patient suffered from attacks of acute paroxysmal pain in the shoulder which could not be accounted for, except as a neuritis of the acromial branches of the cervical plexus. The persistence of these neuralgic attacks, which required large doses of sedatives for relief, and the increasing evidence of a relapse in the angioma, hastened the decision to amputate at the shoulder joint.

Operation—The disarticulation at the shoulder joint was performed under ethylene-gas anesthesia, April 24, 1925, 21 days after the ligation of the subclavian, and after complete aseptic healing of the wound. In amputating at the shoulder joint, hemostasis was obtained by carrying an elastic constrictor around the axilla and over the acromion where it was prevented from slipping by a Wveth pin. The operation was planned to make the arm flap as short and as far away from the angiomatous growth as possible. The axillary contents were cleared—no enlarged or suspicious nodes were discovered, the axillary artery was very large—as large as the normal innominate, and the veins of the arm, superficial and deep, proportionately of large size. The axillary vessels were ligated separately—despite the ligation three weeks previously. While dividing the branches of the axillary plexus, signs of shock suddenly appeared. The blood pressure, which had risen at the beginning of the operation to 158 systolic, suddenly dropped to 118, while the pulse rate rose rapidly from 80 to 152. There had been practically no loss of blood and this sudden shock could not be accounted for, except by the possible effect on the heart of the nerve trauma, or by the sudden drop in the volume of the circulation going through the heart brought about by the amputation of the angiomatous mass. This threatened collapse was averted by a prompt intravenous infusion of hot saline solution, the patient leaving the operating room with a blood pressure of 130/70.

Recovery from the amputation was complicated by a skin infection and later, on the eleventh postoperative day, by a bleeding vein, from which the ligature had been prematurely detached. The bleeding was promptly controlled, but healing was delayed by a hemostatic pack left in the wound for three days, after which the healing progressed rapidly, and the patient was able to leave the hospital, June 11, 1925, about six weeks after the amputation.

Pathologic Anatomy and Histology of the Angiomatous, Amputated Arm—Gross Doctor Lanford. An arm, disarticulated at the shoulder joint (Fig 4), and the same specimen injected with lipiodol (Fig 5) was radiographed before attempting any dissection. The forearm had been amputated at the middle third five years previously (September, 1920) and the stump was most typical of the lesion. "A cross-section through the forearm below the bend of the elbow, cutting through the radius and ulna, exposes the muscular and other tissue planes all fused together and partly transformed into an

erectile cavernous tissue, in which all the anatomic arteries and veins are seen greatly enlarged. The brachial artery measures 1.5 cm in diameter, and its walls about 1 mm in thickness. The vein measures almost 3 cm in diameter. A careful examination shows that the soft parts are universally permeated by a coarse network of blood vessels which, in many areas, has replaced the muscular tissue. There is no degenerated, infiltrated and undifferentiated tissue, but a displacement and replacement of the normal tissues by the overgrowth and dilatation of the blood vessels of the part, from the capillaries up, the largest arteries and veins all seemingly intercommunicating through their branches to form the erectile arteriovenous tissue.

"While much of the angiomatous tissue can be accounted for by the simple dilatation of the normal vessels of the part, as the result of the penetration of the arterial stream into the venous circulation, there is also a large, if not the major part of the angiomatous tissue, that is truly neoplastic. This new growth is in the nature of an homeoplastic



FIG 4.—C. C. age 21. Gross specimen of arm after disarticulation at right shoulder joint, April 24, 1925. Forearm had been amputated at middle third five years previously (September, 1920). A cross section of the forearm immediately above the stump terminal. Specimen had been preserved in kaiserling several months before section was made. Note the great dilatation of the veins, which in life pulsated like arteries. Throughout the whole section the muscular planes are practically replaced by a coarse reticulum of intercommunicating arteriovenous channels (cavernous erectile tissue). Many of the veins are filled with a clot, hardened by the preserving fluid.

hyperplasia in which new blood vessels are born, and multiply in form, true to type, but with restrictions, which differ from the malignant growths, in the fact that the vascular endothelium here arrives at maturity and does not proliferate indefinitely as an atypical embryonic tissue."

The tumor is, therefore, histologically benign, though in its progressive growth, replacement of the normal tissues, and recurrence after amputation, it presents some aspects of malignancy. The photomicrographs, shown in Figures 6, 7 and 8, exhibit sections through the skin and subcutaneous tissue. Here, the normal, but enormously dilated, arteries and veins are shown and, next to them innumerable well-lined endothelial blood passages which carry the arterial blood into the venous system, and which constitute the bulk of the erectile growth. It is the fact that the endothelial and connective tissue cells, of the angioma attain full maturity as blood vessels that gives them their benign character.

Repeated fluoroscopic, radiographic, and electrocardiographic studies were made after the amputation, which confirmed the clinical evidence that the heart and circulation had been vastly improved by the operation. The size of the heart was reduced but still remained large (Fig 9), and "the systolic murmur at the apex radiating upward to the pulmonic area, where it is heard loudest," continued to be heard, but much hushed, as a seemingly permanent relic of the damage created by the primitive arteriovenous fistulae in the angioma. Figure 10 shows the patient as he appeared, January 20, 1926, about nine

months after the amputation. The best proof of the patient's symptomatic improvement was his statement, January 27, 1928, nearly three years after the operation, when he wrote "During the last four years, I have enjoyed the best of health, my only ailments have been a few colds. I have led a normal life, played golf and bowled for exercise, and have done everything in the way of exercise that I have felt inclined to do." Unfortunately, his splendid prospect for continued health was interrupted, August, 1933, when he contracted a lobar pneumonia which overtaxed the heart, and kept him in a critical state until Sep-

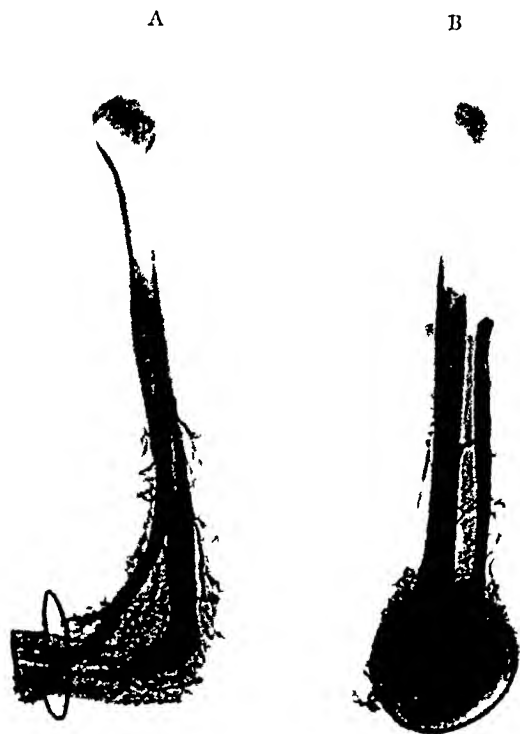


FIG 5—C. C., age 21. Same specimen injected with lipiodol. (A) Lateral view. The circle on the distal side of the stump exhibits a wire constrictor tightened around the stump to prevent escape of the lipiodol through the open vessels. (B) Anteroposterior view. Shows enlarged brachial artery lost at the terminus of the stump in the shadow of the tissues obscured by the radiopaque injection. Note atrophy and decalcification of humerus despite increased vascularity of the bone marrow through the enlarged nutrient and periosteal arteries.

Unfortunately for the picture, the terminal end of the stump had been cut off before the lipiodol injection was attempted, and in this way the view of the final merger of the radial and ulnar arteries with the great pulsating arteriovenous caverns at the end of the stump is lost.

tember 15, when he continued to improve. He had fully recovered and resumed all his normal activities when an unsuspected recurrence of the angioma in the axilla, and another at a distance in the chest wall, brought him back to New Orleans, March 24, 1936, for further investigation and advice.

Metastases Appear 11 Years After the Disarticulation—It would appear, therefore, that a period of nearly 11 years had intervened between the amputation (which, in 1925, had seemingly eradicated the angioma) and reappearance of the angioma in the axillary stump and chest wall early in March, 1936. During these years the patient had been seemingly free from all manifestations of the disease and had no intimation of recurrence until Dr. J. J. Singer, of St. Louis, in the course of a general periodic health examination, made the discovery of the recurrence, which brought the patient back to my clinic, March 24, 1936.

Examination of the patient on arrival fully confirmed the diagnosis of a regional recurrence in the axillary scar of the amputation and another, seemingly a true metastasis, at a distance, in the sixth right anterior intercostal space below and to the inner side of the nipple. These new angiomatous deposits, or formations, presented all the aneurysmal characteristics of the original growth in the arm, namely, a distinct, diffuse pulsation, and a much subdued thrill, a continuous venous hum with systolic reinforcements, also much subdued, all of which ceased on compression of the whole area, only to return when the pressure was removed. The area occupied by the axillary growth is well shown in Figure 11. The angiomatous area presents no recognized boundary line or discoloration of the skin that would indicate its extent. On close inspection, it is seen to fill the upper axilla where the pulsation can be detected by careful palpation over an irregular elliptical

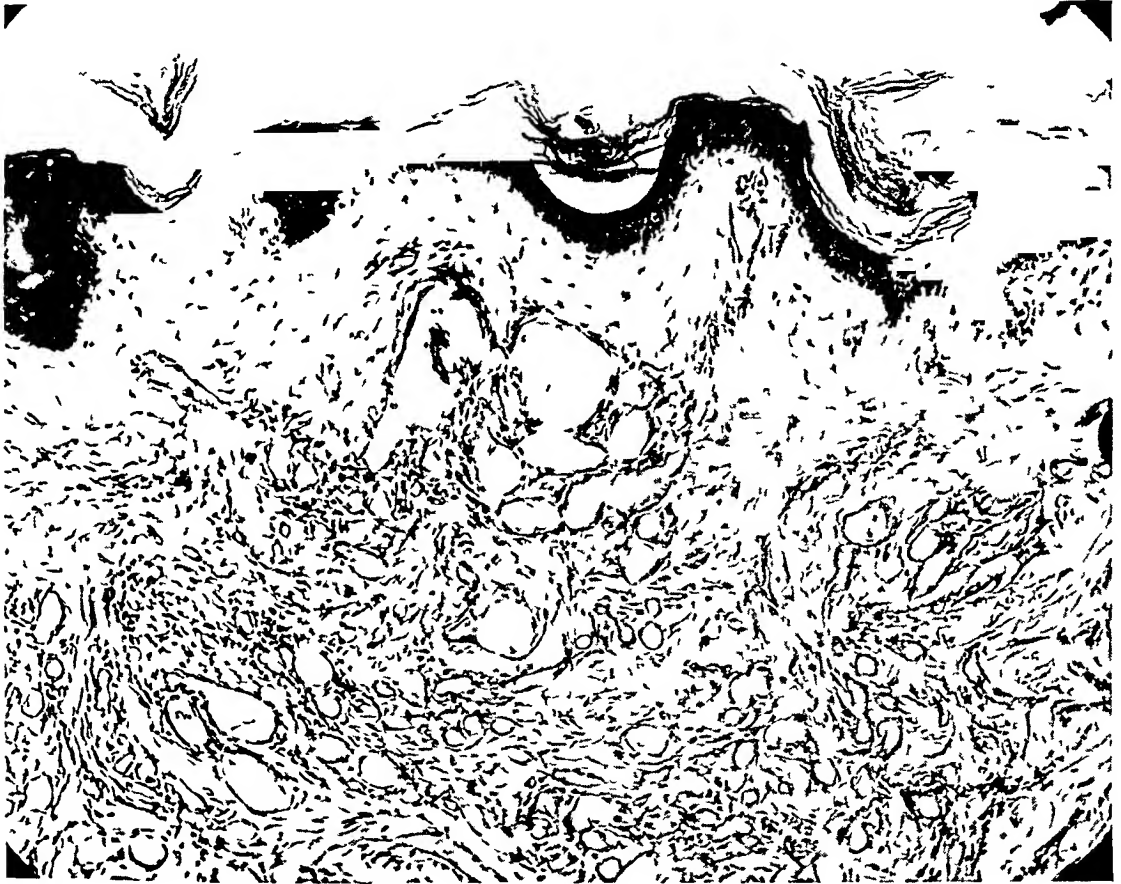


FIG 6—C. C., age 21. Photomicrograph of section through the skin of the angiomatous stump showing large cavernous spaces lying in the subcutaneous connective tissue where the larger spaces are in many places divided by trabeculated septa, all lined with typical mature endothelium. As the section penetrates into the muscular layers and beyond the aponeurotic planes, the lacunar spaces become smaller and the muscle tissue is permeated, and largely replaced, by a fine reticular arteriovenous capillary plexus or network. (Hematoxylin Eosin, $\times 60$) Dr. J. A. Lanford, April 24, 1925.

area 6 or 7 cm long, distinctly involving the fat and subcutaneous tissue to the same extent.

The center of the angioma, and seeming vortex of the circulatory storm, is well indicated in the painted area in and about the scar left by the disarticulation at the shoulder 11 years previously (Fig 12). Here the thrill and the pulsations are fairly well defined by palpation, the systolic murmurs and venous hum being distinctly heard over an even wider area with a stethoscope. These bruits, however, are much moderated and softened in comparison with the murmurs that were heard in the arm before the amputation.

The whole bulging area in the armpit, and below it, is quickly flattened and silenced by compression with the hand. An aspirating needle introduced into the most prominent bulge of the tumor immediately filled the barrel of the syringe with bright red blood,

showing that the arterial current largely preponderates in the circulation of the tumor

In addition to the axillary angioma, a fairly well defined circle of faint pulsation can be detected below and to the inner side of the right nipple, in the area indicated in Figure 14, anterior view. This circular angioma seems to lie deeply under the skin of the intercostal space. There is no discoloration of the skin, or prominence, that would indicate the presence of the tumor. Like the axillary growth, it is an entirely



FIG. 7—C. C., age 21. Section of the same tumor through the muscle tissue showing enormously dilated venous channel. (X60) Dr. J. A. Lanford, April 24, 1925.

subcutaneous formation which lies between the skin and the musculo-aponeurotic planes. In this connection, we realize that these neoplasms are disconnected, the compression and obliteration of the axillary growth having no effect on the thrill, pulsations and murmurs of the intercostal angioma.

In order to explore the interior of the thorax for other possible metastases and determine, if possible, any connection existing between the axillary and intercostal growths, a series of teleroentgenograms were made (Figs. 13, 14 and 15) which show several views during and after the injection of the two angiomas with thorotrast.

From these we judge that the injectable vessels or spaces in each tumor were relatively small in comparison with the vascular areas recognized by palpation and auscultation, and that they did not extend deeply into the thorax, but were seemingly confined

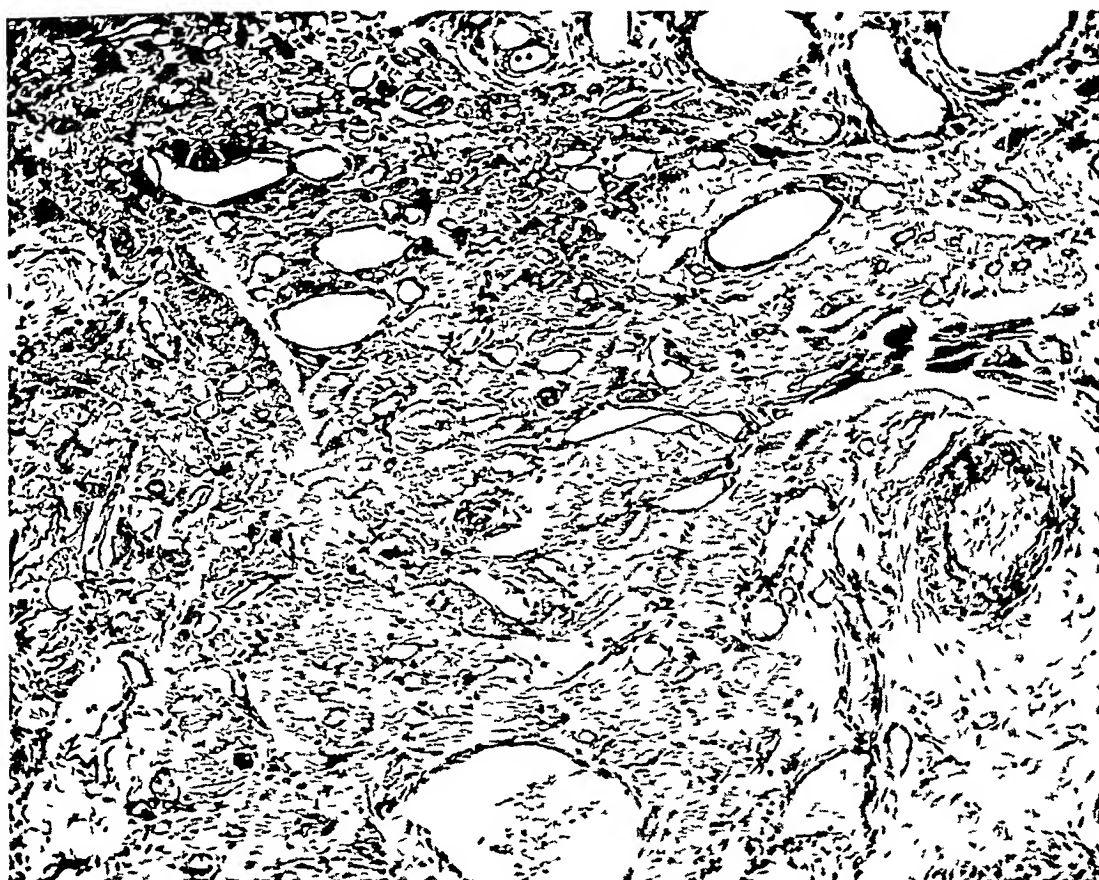


FIG 8—C C, age 21. Section of same tumor ($\times 240$) Dr J A Lanford, April 24, 1925. Note permeation of muscle tissues by dilated blood vessels typical of arteriovenous cavernous angiomata.

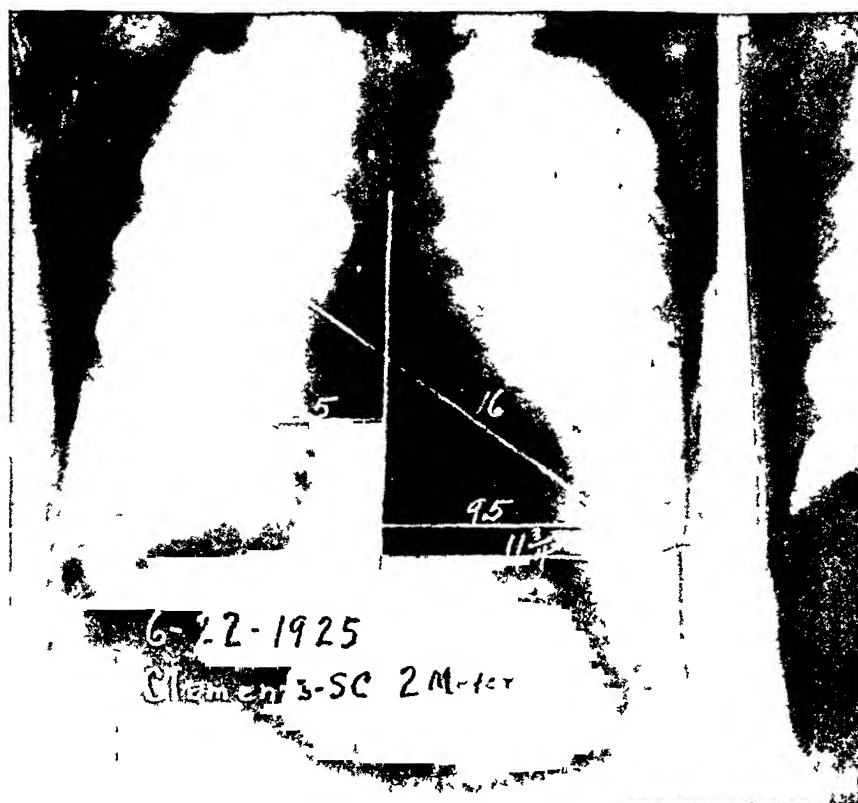


FIG 9—C C, age 21. Postoperative teleroentgenogram of heart, June 22, 1925, two months after amputation of arm.

to the chest wall. The roentgenograms also clearly demonstrated that the two growths were separate and independent of each other. Furthermore, as far as the fluoroscope and films could show, there were no recognizable metastatic deposits in the lungs, mediastinum or heart. The two parietal metastases seem to have been confined to the right half of the chest wall. In considering the practicability of their surgical extirpation, it was also evident that the vascular areas exhibited by the radiopaque injections (thorotrast) represented only the core or vortex of the angiomata, *ie*, where the intercom-



FIG. 10.—C. C., age 22. January 20, 1926. About eight months after the amputation at the shoulder joint, April 24, 1925, the shallow, horseshoe shaped shadow over the right sternoclavicular joint indicates the scar of the incision for the exposure and ligation of the subclavian artery and vein (April 3, 1925). The patient had been completely relieved of his cardiocirculatory symptoms when this picture was taken.

municating channels between the neoplastic arteries and veins were largest and most penetrable to the radiopaque injections. There is no doubt that, beyond these plainly visible central arteriovenous sinuses, there was a widely distributed zone of new or abnormally dilated capillaries which gradually merged with the normal vascular supply of the region.

Preliminary Preoperative Considerations—In conformity with this view of the angiomata, the area to be excised would have to be much larger than that defined by the radiopaque injections. The prophylactic control of hemorrhage in the course of the extirpation was, therefore, a matter that gave serious concern, with the added prospect that, in dealing with the intercostal tumor, the excision of the tumor would be complicated by a pneumothorax.



Fig. 11—C C, age 32, March 26, 1936. Secondary arteriovenous cavernoma of axilla and chest wall, 11 years after disarticulation of the shoulder for same lesion in the arm.

(a) Needle is seen penetrating the most prominent bulge of the angiomatous tumor in the axilla—about to inject thorotrast.

(b) Interrupted lines seen in anterior wall of chest in the subscapular region indicate limits of the arteriovenous murmur which gradually diminished in intensity up to this level, where they ceased sharply. Above this painted line is the scar indicating where the subclavian had been ligated 11 years before.

(c) The dark circular area below and to the inner side of the right nipple was produced by painting the surface with mercuric iodine (radiopaque) solution. The bulge of the pulsating angioma is seen in the center of this area, where loud arteriovenous murmurs can be heard with greatest intensity.

(d) Note the total absence of hair on the right half of the chest apparently a congenital defect.

Fig. 12—C C, age 32. (a) Greatest bulge of cavernous arteriovenous angioma in the axilla in the center of the circular area painted with mercuric iodine. This is the seat of the most intense arteriovenous murmur and venous hum.

(b) The interrupted lines indicate the limit of the audible murmur. This whole area was excised, April 8, 1936.

(c) The scar in the posterior sixth right interspace is the relic of a thoracotomy for empyema when patient was three years old.



FIG 13—C C age 32 March 26, 1936
Radiograph showing injection of thorotrast in secondary axillary angioma

FIG 14—C C, age 32 March 26, 1936
Radiograph showing metastatic angioma in the sixth interspace below the nipple, five minutes after injection with thorotrast. The axillary growth, seen as the opaque injection, is fading away

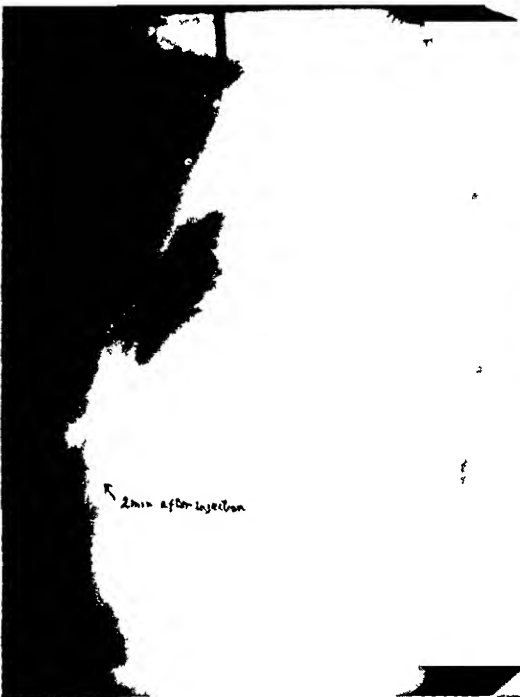


FIG 15—C C age 32 March 26, 1936
Profile view of the intercostal growth in the anterior chest wall, two minutes after injection with thorotrast



FIG 16—C C, age 33 March 2, 1937
teleroentgenogram of heart 14 months after extirpation of axillary angioma

As the axillary growth was the larger, more active, and beginning to thin the skin covering, it was more liable to accidental hemorrhage from trauma, ulceration or spontaneous rupture. It was, therefore, decided to attack this growth first, and reserve the extirpation of the intercostal mass for a secondary operation after the patient's recovery from the first had been assured.

In connection with the roentgenologic studies of the angiomatous growths, several

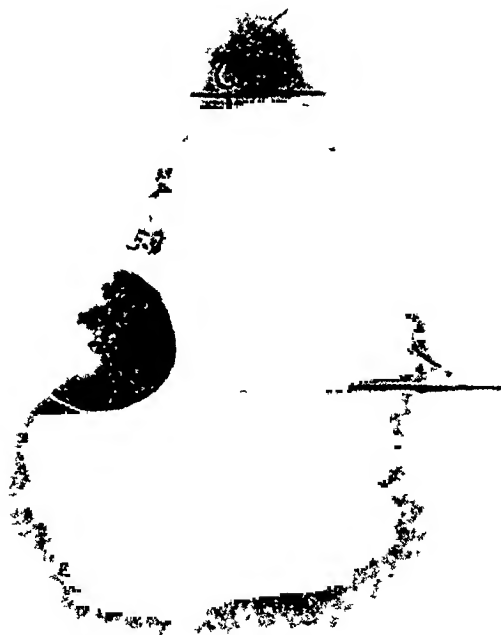


FIG. 17.—C. C., age 32, March 24, 1936. Radiograph of heart (two meter distance) 15 days before extirpation of metastatic angioma in the axilla. Also shows separate intercostal growth enclosed in the circle.

teleoroentgenograms were made of the thoracic contents, especially of the heart and aorta. Figure 16 gives an anteroposterior view of the chest which shows that the dimensions of the heart have slightly increased since the last roentgenogram taken in 1936 (Fig. 17) when it was found that the heart contracted very noticeably after the amputation of the arm. Observations, made at this time, showed that sustained compression of the angiomatous area lowered the pulse rate from 85 to 80 and increased the blood pressure in the arm by a few millimeters—without compression, pulse rate 85, blood pressure 138/70, with compression, pulse 80, blood pressure 140/72. The bradycardiac phenomena of an arteriovenous fistula under compression were present here (Branham syndrome, Nicoladoni-Israel phenomenon) but much less pronounced than when the cavernoma of the forearm was compressed before the amputation of 1925. Corresponding evidence of slight but positive increase in the diastolic interval under compression was also furnished by the electrocardiogram.

Extirpation of Axillary Metastatic Angioma—In the absence of all serious contraindications, the patient was admitted to the Touro Infirmary, April 7, 1936, and the operation was performed the next morning under combined local and general anesthesia. After

a preliminary sedation with nembutal, followed in one hour by a hypodermic of morphine and scopolamine, the skin covering the central core of the angioma was anesthetized with novocain-adrenal solution. After this, the whole pulsating area was densely infiltrated with ephedrine sulphate (1:1,000) in physiologic salt solution. This was injected directly into the blood-filled cavernous spaces of the central core in order to obtain the maximum diffusion and vasoconstrictor effect of the drug on the tissues. The whole peri-angiomatous area was edematized and made hard, pale, ischemic, and pulseless with the same solution injected with a Dunn infiltrator. In this way an elliptic area 15x7 cm. was thoroughly



FIG. 18.—C. C., age 32. Section of villous angioma extirpated April 8, 1936. (X60, H and E stain) Dr. J. A. Linford.

edematized and rendered ischemic and pulseless to the depth of the musculo-aponeurotic planes, thereby completely circumscribing and enveloping the angioma with a vasoconstricting atmosphere which made it possible to attack the tumor in a relatively bloodless zone at the periphery. At this stage the anesthesia was continued with cyclopropane-oxygen gas.

The excision was begun by a curvilinear incision which extended about two-thirds of the circumference of the ellipse which enclosed the angioma (Fig. 12). Despite the marked ischemia that had been obtained by the injection, much time was consumed in controlling numerous vessels which were encountered as the tumor, in solid block, with the skin covering and fat, was lifted out of its deep axillary bed to the depth of the latissimus dorsi and the serratus muscles, which were exposed. After complete hemostasis was obtained by clamps, ligations and electrocoagulation, the excision of the mass *in toto* was effected by completing the elliptic outline of the incision. The solid block of tissue thus excised contained all the recognizable elements of the tumor, including practically all the ephedrine solution (over 250 cc.) which had been injected for the benefit of its ischemic effect.

It is worthy of note that the arteriolar and capillary system in the vicinity of the

angioma showed an increased volume and capacity as the vessels converged centripetally to the central core of the cavernoma, where the arteriovenous channels or sinuses met, as in a confluent, to form the vortex of the angioma

The excision of the angiomatous block left quite a gap in the anterior axilla-pectoral region, but this was readily filled and closed by undermining and mobilizing the walls of the cavity, and holding the cutaneous edges in place with interrupted silk and dermal sutures. The wound was supported with broad adhesive strips and a copious sterile dressing under a Desault bandage



FIG 19—C C, age 32 Section of axillary angioma extirpated April 8, 1936 (X240) Dr J A Lanford

It should be noted that, despite the great care to reduce the bleeding to a minimum by the prophylactic hemostasis previously described, the blood pressure began to fall and the pulse to quicken while the tumor was being excised from its deeper attachments. Without waiting for further evidences of shock, a glucose-saline drip was instituted through the internal saphenous vein at the ankle, and continued throughout the operation until the patient was put to bed and fully restored.

Pathologic Examination—Gross Dr J A Lanford "Specimen consists of an hemangioma removed from the right axillary region. It is covered by an elliptical piece of skin measuring $11\frac{1}{2} \times 6$ cm. The periphery of the skin shows some scar tissue in a limited

area, but most of it is normal in appearance. The under surface of the mass measures $12 \times 6\frac{1}{2} \times 5$ cm, and is made up mostly of adipose tissue which had previously been cut through, showing many large and small blood vessels coursing through the fat, and all converging towards a center nearer the skin surface where the vessels united to form the cavernous areas of the hemangioma.

"A photomicrograph made from a section of the same specimen (Fig 18) shows an irregularly diffused infiltration of the subcutaneous fat by a network of capillaries, which tend to converge, without definite limitations towards a common center where the vessels merge to constitute an arteriovenous confluent or vortex. The lymph nodes of the same region are free from metastatic deposits, though the capsules appear to be involved in the angiomatous process.



FIG 20—C C, age 32. Section of vullary angiomata extirpated April 8, 1936 (X360) Dr J A Linford

"The same specimen, examined with higher powers ($\times 240$ [Fig 19] and $\times 360$ [Fig 20]), shows a connective tissue stroma of a reticulo-endothelial type with a large preponderance of endothelial cells, enclosing numerous blood channels or sinuses of new formation and variable size, lined by well differentiated endothelial cells arranged in cylinders of the same pattern, mostly held together by an outer layer of concentrically arranged spindle-shaped cells. In places, the septa which separate these channels have broken down, thereby creating large cavities or cavernous blood spaces. It is in this respect that this metastatic growth differs from the original parent angioma in the arm (Figs 6 and 8), for in that tissue the normal anatomic vessels, whether arteries or veins, very much dilated from the effect of the congenital arteriovenous fistula, developed into pulsating blood spaces, which are grossly recognized as cavernomata. It was also the preponderance of blood vessels of new formation that gave this metastatic growth a more neoplastic character than that recognized in the parent tumor, which developed largely on a ground-work of preformed vessels."

Subsequent Course—The extensive wound left by the operation, though free from infection, healed slowly. The edges of the wound gave way at the end of one week, leaving an unhealthy, granular surface which bled at the slightest provocation. On one occasion, it became necessary to apply a gauze pack soaked in spirits of turpentine in order

to control the persistent ooze from the granulations. Repeated attacks of intermittent fever, without visceral complications, occurred during the convalescence, which were apparently controlled by quinine, despite the absence of plasmodia from the blood. These attacks prolonged the convalescence until the end of May, 1936, when the wound spontaneously assumed a healthier aspect and began to heal rapidly. While the wound was still being dressed, the patient returned to his home, June 12, 1936.

Roentgenotherapy—After the patient returned to St. Louis, in June, 1936, his wound healed progressively, and by the middle of July, 1936, he was entirely well and had returned to his usual occupation. As planned before his departure from New Orleans, he was given a course of roentgenotherapy, at Barnes Hospital, under the direction of Drs. J. J. Singer and S. Moore. The radiations were applied for the double purpose of (1) Preventing, if possible, a recurrence of the angioma in the excised area, and (2) controlling and obliterating the angiomatous patch below the right breast, which had remained untouched, except for the injection of thorotrast given for diagnostic purposes, March 26, 1936.

The radiations were applied, successfully, to three well-defined areas (mammary A1, axillary A2, and subscapular A3) in accordance with the following formula:

	Area	Portal Sq. Cm.	K. V.	Filter	Dist.	A. U.	M. A.	Min.	Per Cent of Depth Dose	R	{ Ma Min	Total R
10/15/36	A1	225	200	0.5 cu 1 Al	50 cm.	0.13	15	9.2	35	—		550
10/16/36	A2	225	200	0.5 cu 1 Al	50 cm.	0.13	15	9.2	35	—		550
10/17/36	A3	150	200	0.5 cu 1 Al	50 cm.	0.13	15	9.2	35	—		550

A light erythema reaction followed this application. Nothing further was done until August, 1937, when, on a visit to New Orleans, another series of radiations were applied at the Touro Infirmary for three successive days (250 R each, 750 in all) and were concentrated on the circular submammary patch (which had never been operated upon) in accordance with the following formula:

	M. A.	K. V. P.	S. T. D.	Filter	R	Area
8/5/37	20	140	50	0.25 cu 1 Al	250	1
8/6/37	20	140	50	0.25 cu 1 Al	250	1
8/7/37	20	140	50	0.25 cu 1 Al	250	1

A very slight erythema followed this application. The patient continued to do so well, physically, that he married, October 1, 1937 (17 months after the excision of the axillary angioma), and on October 29, 1939, his first child, "a fine, lusty, baby girl," was born without any apparent physical defects. He had been in good health and active during the nearly four years that followed the extirpation of the axillary metastases. He had suffered only from a very transitory attack of lumbar pain which was diagnosed renal colic, without demonstrable calculi.

At my request, the patient has had himself examined by his family physician (Dr. H. D. Spector), who is familiar with his history and who reported, November 30, 1939, that the patient was in excellent general condition, active and working very satisfactorily at his business (furniture store), well-nourished, weighing 145 pounds—a little overweight, pulse 80–90, regular, blood pressure 120/80, temperature normal, and the laboratory tests for blood and urine revealed no abnormalities. Physical examination of the chest revealed some moisture (mucous râles?) at the right base, with no clinical symptoms, however. There was some tenderness and induration of the chest wall at the site of the old submammary angioma, where the thorotrast had been injected four years previously. Apart from this, there were no pulsations, thrills or murmurs to indicate a persistence or recurrence of the angioma in the chest wall. Physical examination of

the chest and abdomen failed to reveal any demonstrable tumors or metastatic deposits. The photograph of the patient (Fig 21), December 1, 1939, confirmed the report of his good health. The telerradiograph of the heart and chest (Fig 22) shows a slight increase in the oblique longitudinal axis (right auricle to apex) as compared with the last radiograph (Fig 16).

The notable fact in this patient's cardiac history is that the heart has never enlarged to the great size it attained in 1925, before the disarticulation of the arm with the angioma (Fig 3), or before the excision of the secondary axillary angioma, in 1936 (Fig 9*).



FIG 21—C. C., age 35, December 1, 1939. Note congenital absence of all hair in right half of chest.

Discussion—The hemangiomata have been classified from the viewpoint of the metastasizing tumors of this class, into the following groups:

(1) Definitely malignant metastasizing hemangiomata (hemangio-endotheliomata, angiosarcomata, *etc*) in which the secondary growths are also, histologically, malignant. Numerous illustrations of this group are quoted by Sonntag,⁷ Wright,⁸ Robinson and Castleman,⁹ Geschickter and Keasbey,¹⁰ Matas,¹¹ and others.

(2) Metastasizing hemangiomata, in which the primary and secondary tumors are seemingly, histologically, benign, the malignancy being recognized clinically, chiefly by the metastatic features, originally a very rare practically unknown group, but now forming a growing list since the first cases were

*For more details regarding the remarkable cardiologic features in this patient's case, see paper by Dr. B. R. Henniger and the author.⁶

reported by Homans,¹² Boormann,¹³ Shennan,¹⁴ Ewing,¹⁵ Sonntag¹⁶ and, later, by Robinson and Castleman,¹⁷ Livingston and Klempeier,¹⁸ Ward and Jones,¹⁹ Hall,²⁰ Abriams, *et al*,²¹

(3) Multiple (nonmetastatic) benign hemangiomas appearing contemporaneously over the body, but particularly in the abdominal visceral organs (liver, spleen, *etc*) (Sonntag,²² Wollstein,²³ Taylor and Moore,²⁴ Matas,²⁵ Jaffe,²⁶ and others)

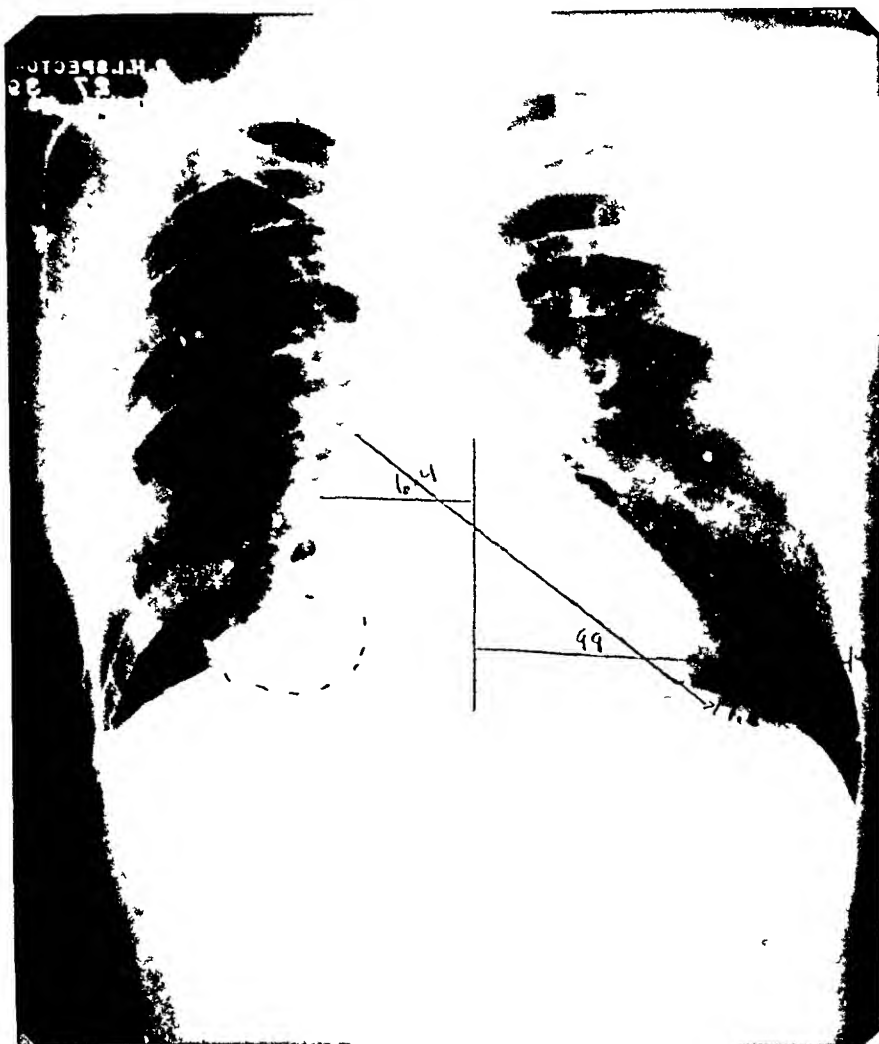


FIG. 22—Teleroentgenogram of heart and lungs—four years after extirpation of axillary angioma. The dotted outline of circle on the right of heart shadow indicates the seat of the inactive secondary submammary angioma which still retains thorotrast injected four years previously.

In the case here reported, we have presented a histologically benign hemangioma of the arm which continued to grow from birth, as an arteriovenous cavernoma from the hand to the axilla, for 21 years, without any apparent metastasis during that period. At the age of 21, the arm was amputated at the shoulder, the patient recovering and remaining entirely well for 11 years. Then two secondary angiomas, of the same histologic type, made their appearance, one in the right axilla, in and about the scar left by the disarticulation, and the other at a distance in the chest wall, in the right submammary region. Clinically and histologically, the two secondary growths were identical with the primary growth as pulsating arteriovenous erectile cavernomata.

The danger of hemorrhage from rupture of one of the caverns compelled

the extirpation of the larger axillary growth. The other, smaller, less active, but deeper in the chest wall, was allowed to remain unmolested, except for two radiations (roentgenotherapy) within a year after the extirpation of the major growth. Thus far, to the date of this report (December 17, 1939), four years have elapsed since the major (axillary) growth was excised, and the patient has remained well, robust and active, without any signs of recurrence or metastases elsewhere in the body, while the smaller, isolated submammary growth has lost its pulsating character and is undergoing atrophic and obliterative changes.

In view of these facts, the question arises whether these secondary growths are really metastases in the true migratory sense of malignant neoplasms or caused by the tardy or postponed development of aberrant, ectopic endothelial cell nests which ultimately develop and come to the surface, as distinct tumors. The old question, "What is it that makes a seemingly typical 'histologically benign angioma,' occasionally and without known reason, suddenly or gradually assume a malignant behavior, which makes it reproduce itself by metastasis?" has never been answered.

It is indeed surprising, as remarked by Shennan long ago, "that despite the fact that innumerable endothelial cells, in all stages of development, must be carried off in the extremely strong and rapid current of an arteriovenous angioma—they are so rarely metastatic, even though the endothelial cells, wherever they are carried, still remain bathed in their normal nutritive fluid."

The increasing frequency with which metastasizing angiomata are being reported would suggest that the capacity of a structurally benign angioma to reproduce itself is not a conclusive criterion of malignancy.

The fact that in this case, metastases did not occur during the 21 years that the angioma flourished in its most active and aggressive form, and that it was not until 11 years after its extirpation that they made their appearance, is a challenge to all the theories clinically invoked to account for the long-delayed appearance of the secondary tumors as metastases, or for their *de novo* appearance as original tumors of separate and independent origin.

Dismissing, as idle, all further theoretic discussions on the nature and pathology of these secondary metastatic angiomata, we regard the mere statement of facts in this very unusual case as worthy of record, if only as an encouragement to others who may be faced with a prognostic problem of the same initial gravity which has evolved into a later cheerful outlook.

NOTE.—While this article is going through the press, Dr. Spector writes that, on March 11, 1940, Mr. C. C. was reexamined, with special emphasis on evidence of persistence or recurrence of angiomatous signs in the areas previously involved in the metastases. The examination only confirmed the patient's good health and normal activities and complete absence of angiomatous lesions in the chest or elsewhere, as stated in the previous report, above quoted. The cardiologic tests, including electrocardiograms, teleoroentgenograms, etc., show no notable changes since the report of December 17, 1939. In view of the total suppression of pulsation, thrill and murmurs in the unexcised angiomatous area injected with thorotrast (which has remained unabsorbed in the tissues since it was first injected,—over four years) and of the systematic roentgenotherapy to which the angiomatous area was subsequently subjected—it is a question whether the

apparent cure has been obtained by inducing an obliterative vascularitis in the angioma through the separate or combined efforts of the thorotrast and roentgenotherapy, or by some other unknown factor

BIBLIOGRAPHY

- ¹ Pemberton, J deJ and Saint, J H Congenital Arteriovenous Communication Surg, Gynec and Obstet, 46, 470 1928
- ² Matas, R On the Systemic or Cardiovascular Effects of Arteriovenous Fistulae Trans Southern Surg and Gynec Assn, 36, 623, 1923
- ³ Branham H H Int Jour Surg, 3, 250, 1890
- ⁴ Nicoladoni Arch f klin Chir, 18, 252 1875, 20, 1876
- ⁵ Israel, J Arch f klin Chir, 21, 109, 1877
- ⁶ Matas, R and Heninger, B Reversible Cardiac Enlargement in a Case of Congenital Cavernous Hemangioma Am Heart Jour, 17, 131-137, February, 1939
- ⁷ Sonntag, E Die Haemangiome und ihre Behandlung Ergeb d chir u Orthop, 8, 1, 1911
- ⁸ Wright, A W Primary Malignant Hemangioma of Spleen with Multiple Liver Metastases Am Jour Path, 4, 507-524, 1928
- ⁹ Robinson, J M, and Castleman, B Benign Metastasizing Hemangioma ANNALS OF SURGERY, 104, 453-459, 1936
- ¹⁰ Geschickter, C F, and Keasbey, L A Tumors of Blood Vessels Jour Cancer, 23, 568-591, 1935
- ¹¹ Matas, R Vascular Tumors Cyclopedia of Medicine F A Davis & Co, 12, 798-878, revised 1934 (see Pathogenic Theories, 814)
- ¹² Homans, John Report of a Case of Cavernous Angioma of the Spleen ANNALS OF SURGERY, 25, 732-734, 1897
- ¹³ Borrmann, R Metastasenbildung bei histologisch gutartigen geschwulsten Beitr z path Anat u z allg Path, Jena, 40, 373, 1907
- ¹⁴ Shennan, Theodore Histologically Nonmalignant Angioma—with Numerous Metastases Jour Path and Bact, 19, 139-154 1914-1915 Note Homans and Borrmann are fully quoted by Shennan, as the first reports to appear in the literature of the metastasizing angiomata, with Shennan's own case as the third of the first series which, together, constitute the primordial foundation on which the growing literature on this subject now rests
- ¹⁵ Ewing, J Neoplastic Diseases, Saunders, Philadelphia, 2nd Ed, 223-233
- ¹⁶ Sonntag, E Loc cit
- ¹⁷ Robinson, J M, and Castleman, B Loc cit
- ¹⁸ Livingston, S F, and Klemperer, P Malignant Angiomata with Reference to the Question of Sarcoma Due to Roentgen Ray Arch Path and Lab Med, 1, 899-910, 1926
- ¹⁹ Ward, E, and Jones, A F Metastasizing Hemangioma Simulating Aneurysm Arch Surg, 36, 330-335, February, 1938
- ²⁰ Hall, E M A Malignant Hemangioma of the Lung with Multiple Metastases Am Jour Path, 11, 343-351, 1935
- ²¹ Abrams, J Histologically Nonmalignant Metastasizing Hemangioma, with Report of a Case Ann Int Med, 13, 883-895, November, 1939
- ²² Sonntag Loc cit
- ²³ Wollstein, Martha Malignant Hemangioma of the Lung with Multiple Visceral Foci Report of a Case Arch Path, 12, 568-571, 1931
- ²⁴ Taylor, A C, and Moore, E Multiple Hemangioma Showing Certain Malignant Characteristics in an Infant Am Jour Cancer, 19, 31-39, 1933
- ²⁵ Matas, R Vascular Tumors Loc cit
- ²⁶ Jaffe, R H Multiple Hemangiomata of the Skin and Internal Organs Arch Path, 7, 44-54, 1920

CASE OF LARGE FALSE ANEURYSM OF THE RIGHT SUBCLAVIAN ARTERY SUCCESSFULLY TREATED BY A MODIFICATION OF THE MATAS OPERATION *

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THIS CASE IS reported because of the method of its treatment, which, I hope, may make possible the cure of some aneurysms with a blood supply uncontrollable by tourniquet or ligature.

Case Report—R. P., white, male, age 41, was admitted to the Indiana University Hospitals, February 28, 1939, for a large aneurysm of the right side of his neck. He complained also of weakness, loss of sleep and shortness of breath on slight exertion.

In April, 1921, a .38 caliber bullet had entered the midline of his neck, two inches above the suprasternal notch, and had lodged in his right axilla. A small swelling appeared at once above his right clavicle. In a week he had recovered sufficiently to visit the Mayo Clinic. Since he was there given no suggestion on treatment, he apparently had no aneurysm at that time. On his return home, the supraclavicular swelling began to pulsate, and six weeks after the injury his right axillary artery was ligated. Following this his entire right arm and forearm were paralyzed, and remained so for about seven months, when a partial recovery began.

During the next 17 years he complained of shortness of breath, which made him unable to walk more than two or three blocks without resting. During this time the lump above his right clavicle did not bother him or change in size.

In July, 1938, he had a severe attack of heart failure attended by seven weeks of orthopnea and cough. In October, 1938, he had bilateral pneumonia and developed a marked edema of his entire body. During this illness late in October, 1938, after severe coughing, the pulsating swelling appeared, and reached, almost overnight, the size seen on admission. The mass had not increased greatly in size during the four months since its appearance. The remainder of the history is irrelevant.

Physical Examination—The patient was powerfully built and well nourished. The right pupil was contracted and the right palpebral fissure narrowed. The veins of the right arm and right side of head and neck were not dilated. There was marked atrophy and weakness of the right arm and forearm.

Dr. George Bond, after an examination of the cardiovascular system, reported considerable enlargement of the heart, hypertension and mild cardiac decompensation. He found the blood pressure in the left arm to be 165/110 and in the right arm 120/110.

The usual laboratory examinations showed nothing abnormal.¹ All tests for syphilis were negative. The aneurysm was the size of a large grapefruit (Fig. 1), and pushed the patient's head to the left. It extended from the midline in front to the anterior edge of the trapezius muscle. It overhung the inner half of the clavicle and the right sternoclavicular joint, and extended upward almost to the jaw. It displaced the trachea about two inches to the left (Fig. 2). The skin over it was black and shining and seemed in imminent danger of rupture at each violent expansion of the mass. The antero-inferior portion of the aneurysm was firm to the touch, the other portions, resilient. No thrill was felt except along a line extending from the suprasternal notch along the internal surface of the aneurysm. We ascribed this finding to compression of the common

* Read before the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

carotid artery. A very loud systolic bruit was heard over the entire swelling. Roentgenologic examination showed that the aneurysm did not extend below the first rib.

The foregoing data seemed to warrant the following conclusions:

(1) The aneurysm arose from either the first or second divisions of the subclavian artery, possibly from both.

(2) Ligation of the first portion of the subclavian artery or of its branches would be perilous or impossible, because of the location of the aneurysm and its long duration. Ligation of the innominate artery would, at best, only diminish the blood entering the aneurysm.

(3) There was but one opening into the aneurysm and this was probably large.

No act of a surgeon is considered more foolhardy than to cut into a live aneurysm, but I decided to do it because I had no other choice. The operation was planned as follows: (1) Constriction of the innominate artery, (2) wide incision of the aneurysm, and digital occlusion of its opening into the subclavian artery, (3) intrasaccular closure of the opening, (4) preparation for massive blood transfusion.

I am very grateful to Dr. John Owen for his able assistance in the operation.

Operation—March 7, 1939. Fifteen hundred cubic centimeters of blood was obtained from three donors and preparations were made for its immediate injection when needed, by way of a vein in the right leg. Under ether anesthesia the incision was started over the anterior edge of the left sternocleidomastoid muscle, three inches from the sternum and extended downward over the left sternoclavicular joint, thence diagonally across the body of the manubrium and downward a short distance along its right border. The left sternoclavicular joint was excised. The manubrium was rongeuried away from above downward and from left to right until a good-sized opening was obtained. The ribbon muscles were divided. The innominate artery, the diameter of an index finger of average size, was freed and a ligature passed around it on an aneurysm needle. The assistant now constricted the artery by pinching the ligature with the thumb and index finger of his left hand. This stopped pulsation of the aneurysm, but did not diminish its size or tenseness.

A second incision about four inches long was now made over the most prominent portion of the aneurysm and parallel to the clavicle. The assistant instantly thrust his right hand into the aneurysm through the escaping blood and plugged the opening in the subclavian artery with his finger. The opening was about one and one-half inches long and a little less than half an inch wide. It was situated just above the inner end of the clavicle. I removed some adherent masses of clot and examined the walls of the aneurysm. The edges of the opening were thin and the bottom of the sac for a considerable distance around the opening was of cartilaginous hardness. It was evident that the opening could not be closed by suture and that ligation of the artery through the sac wall could not be accomplished.

After a period of anxious thought, I decided that the only possible way to close the opening was to plug it with a piece of the sac wall. This I did as follows. First, I separated the sac from the skin and subcutaneous tissues as far as was easily possible. Since the peripheral half of the sac was necrotic, I cut it away. By sharp dissection I next freed the lateral and inferior portion of the sac, where there was no danger of injury to important structures, down to the upper border of the clavicle. I next fashioned a flap from this portion of the aneurysmal wall, as shown in Figure 3-1. The base or hinge of this flap was located at the upper border of the clavicle. The flap was about three and one-half inches long. It consisted, of course, of condensed connective tissue and was a little less than a quarter of an inch thick.

I now placed three sutures across the finger of my assistant as follows. With a short, full curved needle I took a good bite of the sac as close to the opening as possible, then a like bite on the other side. One suture was so placed at each end of the opening, and one at the middle (Fig. 3-1). I now passed a hemostat beneath the central portions of these sutures, seized the apex of the flap (Fig. 3-2) and pulled



FIG 1—Patient on admission



FIG 2—Roentgenograms showing displacement of trachea to the left The aneurysm does not extend below the first rib

it over the obstructing finger, which was then withdrawn. There was a quick gush of blood which was stopped by packing the flap into the opening where it was held by tying the sutures over it. The flap was further secured by a number of interrupted sutures which fastened its edges to the adjoining wall of the sac. We now freed the remainder of the distal part of the sac from the surrounding tissues, taking care not to free its base where important structures might be injured. The freed portions were now trimmed and cut so that they could be firmly imbricated by sutures over the flap (Fig. 3-3).

The ligature was now removed from the innominate artery, and the wounds closed without drainage (Fig. 3-4). The dressing was strapped firmly over the site of the aneurysm.

While the wounds were being closed the patient was given 600 cc of blood. His pulse rate at the beginning of the operation was 96 and his blood pressure 170/110, at the close, his pulse was 92, and his blood pressure 118/60. The loss of blood, except for that in the aneurysm, was not great.

Postoperative Course—Convalescence was satisfactory. The dressing was first changed on the ninth day, at which time primary healing had occurred. No bruit could be heard at the site of the aneurysm.

On the twelfth day after operation, shortly after getting out of bed for the first time, the patient had severe precordial pain and shortness of breath. His blood pressure at the onset of this attack was 130/95, but in three hours it had fallen to 85/50. His condition gave us much anxiety for several days. Dr. George Bond, who attended him at this time, made a diagnosis of acute myocardial failure. Recovery was fairly rapid, but we enforced bed rest until dismissal, April 15, 1939.

Subsequent Course—The patient was recently examined. He is now, eight months after operation, up and about constantly and supervises a small business. It is astounding that there is not the least swelling or induration at the site of the aneurysm (Fig. 4), nor any thrill or bruit. He has gained 40 pounds. His blood pressure is now 210/120. The Horner syndrome has disappeared. The condition of the right arm is as before operation.

Discussion—I can find no instance of the treatment of an aneurysm by the method employed in this case. McNealy and Shapiro¹ report the use of pedicled transplants of muscle within the sacs of two aneurysms, one of the third part of the subclavian, and one of the femoral. In both cases, however, the transplants were not inserted until after control of the blood supply by proximal and distal ligation. These writers report some interesting experiments on the effects of loosely inserted pedicled muscle transplants within arteries. They found "that the intimaluminal part of the muscle graft atrophied. After one or two weeks it had disappeared, but as it shrank it was replaced by a severe obliterating endarteritis. No trace of intimaluminal muscle or clot was found after three months, but only an intimal cushion which completely, or almost completely, occluded the lumen and left only an occasional narrow, limited channel along the opposite wall. The segment of artery involved was reduced after six months to a fibrotic cord with the muscle graft still attached to its wall."

Reid² has done the only experimental work I can find on complete occlusion of arteries with fascial plugs. He states "When balls of fascia are introduced into the lumen of an artery and anchored by a suture of silk, complete occlusion may be accomplished without much damage to the arterial wall save for some atrophy at the site of the plug. This plug produces complete occlu-

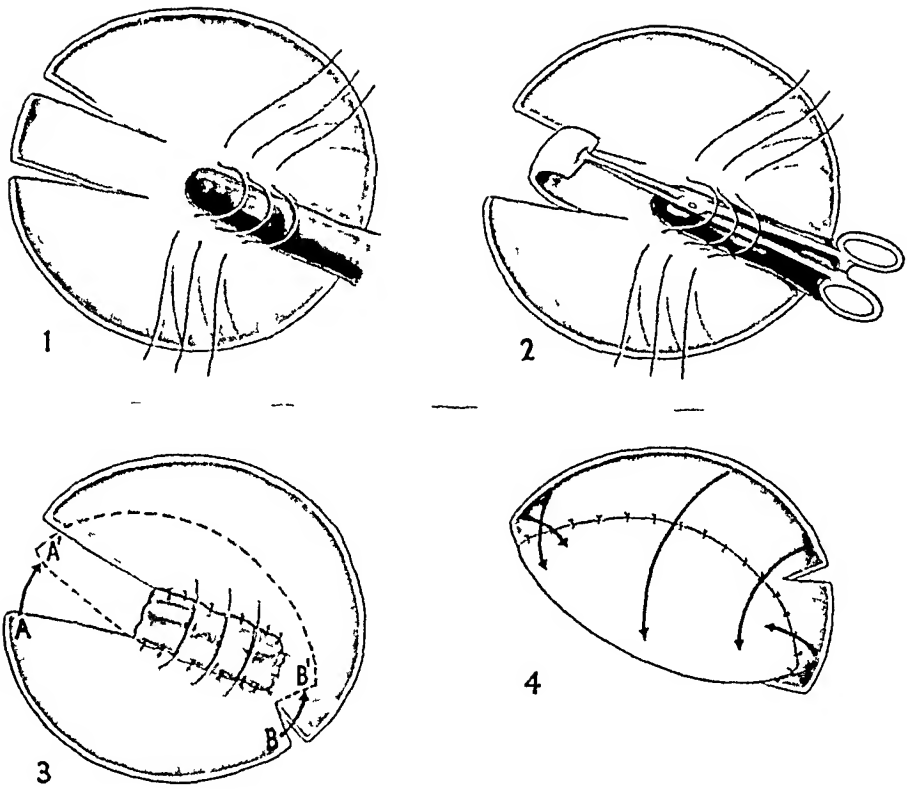


FIG 3--Showing the steps of the operation



FIG 4—Patient eight months after operation

sion and at its point of contact with the blood stream it becomes covered with intima" He also states that "the fascial plugs remain as viable tissue and do not become substituted by fibrous tissue, that where the fascial plugs come in contact with the blood stream they become covered by intima For such a method of occlusion there would seem no practical demand" He believes that the organization of thrombi in the region of the plug comes chiefly from the media and adventitia rather than from the intima

I was greatly impressed by the success in the case I have reported, of obturation of the artery A free plug of sac wall would probably have done just as well as a flap It is unlikely that the distal part of the flap received any nourishment from its own blood vessels The protocols of the experiments of McNealy and Shapiro convince me that this was true of the circulation in their muscle transplants

False aneurysm of the subclavian artery is rare because wounds of this vessel are liable to be immediately fatal Lee, Mitchell and Peacock³ could find only 129 recorded cases in the 172 years ending in 1934 False aneurysm of the first and second portions of the vessel is extremely rare and its operative cure is regarded by all writers on this subject as always difficult and often impossible I hope the method I have described may have at least a limited field of usefulness in the cure of these false aneurysms situated above what Halsted has called 'the domain of the tourniquet' It involves, of course, free incision of the aneurysmal sac before its blood supply has been controlled, but by use of the plug of sac wall it provides a ready and easily applied method of controlling the hemorrhage The operation reported could probably have been accomplished without preliminary constriction of the innominate artery, but this certainly added to its safety

The method would seem well suited for the cure of false aneurysms of long standing It can be most easily performed when ligation and excision are most difficult It should certainly not be tried until after the aneurysm has been present for two or three months, that is, until the false sac has become fully developed This is no disadvantage, however, because it is generally recognized that operation before the formation of the false sac is very dangerous The method has all the advantages of ordinary endo-aneurysmorrhaphy and gives extraordinarily firm and secure closure of the arterial wound There is no reason to believe that it is any more likely to cause embolism than is ligation

REFERENCES

- ¹ McNealy, R W, and Shapiro, P F Arterial Repair by Muscle Transplants *Surgery*, 2, 61, 1937
- ² Reid, M R Partial Occlusion of the Aorta with Silk Sutures and Complete Occlusion with Fascial Plugs *Jour Exper Med*, 40, 293, 1924
- ³ Lee, W E, Mitchell, C F, and Peacock, A B Traumatic Aneurysms of the Subclavian Artery *ANNALS OF SURGERY*, 100, 87, 1934
- ⁴ Halsted, W S Ligations of the Left Subclavian Artery in Its First Portion *Bull Johns Hopkins Hosp*, 21, 1, 1924
- ⁵ Matas, R Article on Surgery of the Vascular System *Keen's Surgery*, W B Saunders Co, 5, 1909

DISCUSSION —DR BARNEY BROOKS (Nashville, Tenn) It would be too bad if the presentation of these two papers were not coupled with at least a recognition of an appreciation of their meaning. I should like first to call attention to the courage shown by Doctor Gatch in undertaking the difficult task of cure of the aneurysm in the patient he presented. Anyone who undertakes the operative treatment of large aneurysms so situated that it is impossible to obtain complete control of the blood supply to the sac, is fully aware of the courage and skill necessary to success from a bold incision into the tense aneurysm sac. James Syme and other pioneer surgeons have graphically described experiences before the days of antiseptic surgery, when this method was the only one which could be employed in the treatment of aneurysm. I assume that Doctor Gatch was unable to expose the common carotid in the neck. This would have given him additional control of the blood supply to the aneurysm sac.

As to Doctor Gage's paper, I would like to point out the fallacy of comparing gangrene after wounds of arteries in war to that following similar wounds in civil life. Certainly, the estimation of the occurrence of gangrene in 40 per cent of cases in which the popliteal artery is occluded is greatly in excess of that we have found to follow obliteration of this vessel in ordinary civil practice. As a matter of fact, we have not encountered a single instance of gangrene following obliteration of the popliteal artery from operations for wounds or aneurysm in this vessel.

I wonder if Doctor Matas considers the case which he presented as perhaps belonging in that group of varying anomalies constituting von Recklinghausen's disease. I remember quite well an operation upon a similar case some years ago in which the patient died from embolism from air sucked into the veins from large blood spaces opened at the time of operation. All of these papers are of extraordinary interest to those of us who have been pupils and followers of Doctor Matas in the development of surgery of the vascular system.

DR A W ALLEN (Boston, Mass) I also wish to express my appreciation of this symposium. It has been a great pleasure to listen again to the great master, Dr Rudolph Matas, on this interesting subject. I wish to congratulate Doctor Gatch on the very ingenious manner in which he so successfully carried out the operation upon his patient.

We do not see, in New England, many aneurysms of the luetic variety and have few cases of arteriovenous fistula. However, we have our share of arteriosclerosis and have had a number of instances of sudden thrombosis in the dilated popliteal artery followed by gangrene of the extremity. We have seen a few cases of arteriosclerotic popliteal aneurysm that have come to us prior to thrombosis. In every instance, when these patients have gone on to thrombosis, gangrene has developed. There have been no exceptions in this group. Recently, however, we had a patient with a popliteal aneurysm of the arteriosclerotic variety at a time when Doctor Ochsner was visiting us. He told us of the work Doctor Gage was doing in blocking the sympathetic plexus and advised our trying it. We did so with novocain and then with alcohol, and were much impressed with the diminution in size of the dilated vessel following the procedure. The patient was discharged from the hospital in a few days and, two weeks later, became aware of the fact that the pulsation behind his knee was gone. We were greatly interested to know what was going to happen to him. We expected that he would develop gangrene. He had had a good deal of intermittent claudication. He did not de-

velop gangrene but he continued to have about the same amount of claudication as prior to the thrombosis. I am convinced that the sympathetic block kept him from losing that extremity. For this reason it is apparent to us that Doctor Gage has made a valuable contribution. He deserves a good deal of credit for calling to our attention the beneficial effect of sympathetic block in such cases.

DR J. M. MASON (Birmingham, Ala.) In listening to these remarkable and interesting papers, one scarcely knows where to begin a discussion, as there are so many important features connected with each reported case.

In the patient of Doctor Gatch, the important thing is that he was able to control the main arterial blood supply before opening the aneurysmal sac.

I have found that the following steps, by no means original with me, but employed successfully in dealing with aneurysms and arteriovenous aneurysms of the subclavian-axillary vessels, give adequate exposure for any operative attack upon the vessels of this region distal to the anterior scalene muscle.

(1) Skin incision. Beginning at upper border of the thyroid cartilage over the outer border of sternomastoid muscle, down to its clavicular attachment across the upper surface of the clavicle to its outer third thence downward and outward to the axillary border.

(2) Dissection and retraction of skin flaps, retraction inward of sternomastoid to expose the scalenus anticus, retraction of this muscle to permit access to subclavian artery as it emerges from behind the muscle.

(3) Division of the clavicle, division of the clavicular attachment of the pectoralis major, of the subclavius muscle, and of the tendon of the pectoralis minor.

(4) Retraction of the divided clavicle to permit access to the subclavian vein as it crosses in front of the scalenus anticus and passes beneath the clavicle.

(5) Reconstruction of the wound in proper anatomic planes, after the vascular lesion has been dealt with.

It may be well to call attention to certain points concerning operations upon vascular injuries or disease in this region.

The subclavian vein should be occluded proximally before any opening is made into this vessel. Failure to do this has resulted in fatal air embolism, as reported in Makin's series.

The subclavian artery should be occluded proximally before freeing the clavicle from an aneurysmal tumor. The clavicle has sometimes been found so eroded that it forms part of the sac wall, and in separating it, the aneurysm may be opened with disastrous results.

The treatment of the divided clavicle has been the subject of some discussion. It is claimed that no material disability follows its removal, and in the one case in my series where the anterior half was removed, the function of the shoulder and upper extremity was not impaired. In reviewing a series of 19 cases, the disposition of the clavicle was not noted in three instances, it was wired three times, and removed, wholly or in part, in eight instances. I have removed the inner half in one instance, and have wired the divided bone in three cases.

Undoubtedly, the presence of a compound fracture of the clavicle protracts the convalescence, and, in the case of infection, the period of recovery may be much delayed.

DR JOSEPH A. DANNA (New Orleans, La.) We sometimes make an incision into an aneurysm without knowing we are dealing with one. In such

an event, if you put your finger in the incision you have made, at the same time that you control the external flow of blood, you can feel the blood spitting in through the main opening and circulating in the sac. By applying the finger to the easily palpated aneurysmal opening, the blood flow is stopped and the aneurysm may be ripped open and its openings sutured. I have done this on two occasions. In some cases there may be a second or third vessel opening into the cavity. In that case put your finger in one, have your assistant put his finger in the other, and you can go on with your work.

DR J L CAMPBELL (Atlanta, Ga.) Vascular surgery is a field in which we owe much to Doctor Matas. He has been the real pioneer and his work has inspired all of us who have come in contact with patients having lesions of the blood vessels.

Prior to 1930, when I had charge of the Surgical Department of the Emory University division of Grady Hospital, I saw many interesting aneurysms. The most difficult ones to handle are those of the subclavian and the femoral in Scarpa's triangle.

Doctor Gatch is to be congratulated on the successful outcome of his case. If we remove the whole clavicle, or at least the inner two-thirds of it, the approach to the vessels is much easier. Then we are able to expose them more easily, both proximal and distal to the anastomosis. A Dakin tube can be passed around them and clamped without danger of injury. While this will not always insure a dry field, it will enable us to determine whether we wish to attempt a restoration or simply perform a quadruple ligation and resection. Quadruple ligation without resection will not insure a cure. Resection of the vein and artery between quadruple ligatures rarely causes any trouble, for the collateral circulation is almost invariably well established. When the clavicle has been resected subperiosteally it will cause no inconvenience to the patient. One of my patients drove a taxi ten years after his clavicle was removed. I doubt if he ever missed it or he may never have known that it had been removed. I have resected or removed the clavicle in ten or more patients without any functional inconvenience.

We should always try to restore the continuity of the vessel in fistulae of the common carotids and internal jugular vein. Of course, the collateral circulation can be stimulated by daily pressure on the vessels at the point of anastomosis and, when all indications of cerebral anemia have disappeared, the vessels can be resected, but when the lumen of both has been restored you can feel much more comfortable. This is the most favorable location for a restorative procedure because there are no branches to be encountered or controlled, simply expose the artery and vein above and below the fistula, pass the Dakin tubes around them and clamp. Then separate the vessels and suture the opening. In my early cases I placed a strip of muscle over the suture line, then over that a band of fascia. In my later cases I only placed a strip of muscle between the vessels and closed the sheaths.

Repair of an arteriovenous fistula in Scarpa's triangle gives more trouble than in any other location. In three cases I felt sure the fistula was between the femoral vein and artery but after a further search I found it about 1 cm from the femoral in the profunda. There is no debate in one's mind about the procedure to take in these, for it is easy to perform a quadruple ligation and divide the vessels at the fistula. If the vessels are not divided and the sac removed (if there is one), the patient will not be cured.

DR MIMS GAGE (New Orleans, La., in closing) I wish to thank both Doctor Brooks and Doctor Allen for their kind discussion. I am very glad

that Doctor Allen has had success in developing the collateral circulation in his cases of peripheral aneurysms by blocking the sympathetics. I think that Doctor Brooks misunderstood my remarks in regard to the high incidence of ischemic gangrene in war wounds of the femoral and popliteal arteries. It was my purpose to demonstrate that the inherent qualities of all aneurysms are to develop collateral circulation, whereas the sudden occlusion of a normal peripheral artery invokes a high incidence of ischemic necrosis. I think that Tuffier reported an incidence of 66 per cent gangrene in 24 ligations of the popliteal artery in contrast to Matas' 5.2 per cent of gangrene following 154 personal operations for popliteal aneurysms, clearly demonstrating the differences that exist between normal peripheral vessels and those diseased with aneurysms. Another typical example is the high incidence of gangrene that occurs following peripheral arterial embolism. I believe both the above comparative pictures definitely indicate that release of vasospasm of both the main arterial tree as well as the collaterals is of foremost importance before ligation of the peripheral arteries in the treatment of aneurysms is undertaken.

DR. RUDOLPH MATAS (New Orleans, La.) There is such a wealth of information in Doctor Gage's and Doctor Gatch's papers and so much that is new and informative in the discussions that followed, that it seems to me we could spend the entire evening profitably by going over the ground they have covered. I feel that the Chairman has been so indulgent and the members who have spoken have been so generous in their praise of my unpretentious work that it would be best that I should only thank them—which I do very sincerely—and say no more. I would, however, like to avail myself of this opportunity to express my heartfelt gratitude to many of my former pupils, here and elsewhere whose loyalty and generous praise touch me deeply. After hearing Doctor Gage's frequent and flattering references to my vascular hobbies, you should not be surprised if I blew up with vanity.

Doctor Gatch's operation was such a brilliant performance that it deserves our warmest congratulations. Those who are not immersed in this kind of surgery can scarcely realize the great tension, the anxious moments, and the worries that are involved in these deep-neck performances. Doctor Gatch's operation is, I believe, unique in utilizing a flap from the sac to close the chief orifice of arterial supply. The whole conduct of the case shows great ability to think quickly and act successfully, on the spot, in a critical situation.

Again gentlemen I thank you all for your kindness to me!

HYSTERICAL EDEMA OF THE HAND AND FOREARM *

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MANIFESTATIONS of major hysteria which simulate surgical lesions are numerous and well known. Such conditions are not usually accompanied by change in the structure of the part involved but rather are manifested by an apparent loss of function. Hysterical seizures are usually defense reactions and the major examples are designed by the individual as a means of protection against problems of life which he feels unable to successfully combat.

Edema in localized areas of the body may be the result of a number of factors. Among these is venous congestion (Loeb¹). When such congestion is due to increased venous pressure, there is dilatation of venules and capillaries from this increased pressure and an increased exudation of fluid into the tissue spaces. As fluid increases in the tissues the pressure here is increased and there are also changes in the osmotic tensions of both inorganic salts and proteins, so that a point may be reached where exudation will cease when the tissue pressure equals or exceeds the combination of osmotic and vessel pressure (Youmans *et al*²).

When there is interference of outflow of fluid from the tissues through both the venous and lymphatic channels this increased tissue pressure results. Youmans³ has shown that there is a marked increase in the circulating time of the blood in the leg on quiet standing. He has also demonstrated a considerable increase in leg volume after quiet standing. The speed of blood flow is increased by motion and increase in volume does not occur. He believes that much more fluid is actually passed from the capillaries into the tissue spaces during this period, but it is removed by the improved venous and lymphatic return circulation. The amount of blood passing through the small vessels is also increased by the improved return and this promotes increased exudation of fluid.

Wells, Youmans and Miller⁴ have found increased tissue pressure in various parts of the leg after periods of quiet standing and have found that marked increases occur in muscles which are covered by stout fascia, such as the anterior tibial group, a much smaller increase is present in the gastrocnemius which has a thin fascia, and only a slight increase is found in the subcutaneous tissue. Landis and Gibbon, Jr,⁵ demonstrated edema in the forearm from congestion produced by a pneumatic cuff on the arm and measured by a "pressure plethysmograph" on the forearm. This apparatus eliminated measurement of the increase in forearm volume due to increased blood in the veins. During the first part of the experiment the venous congestion accounted for the major portion of the increased volume, but after

⁴ Read before the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga. December 5, 6, 7, 1939.

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30 minutes the congestion did not increase, so that later increase in volume was due to increased fluid in the tissues. They found that the filtration rate increased with increasing venous pressure, and with a constant venous pressure the rate declined with increase of tissue pressure.

Many cases of hysterical paralysis have been reported but in most of these cases the lower extremities are involved following an injury to the back. Parker⁶ reported a case of hysterical paralysis of the arm in a young



FIG. 1.--Case 1. Condition of arm on admission to hospital.

woman. There was no circulatory disturbance in this case because the position of the forearm was either held at a right angle to the arm by bandage or the position was frequently changed.

A search of the literature (admittedly not complete) of the last 20 years fails to find a report of edema of the forearm and hand produced by the immobile dependent position of the extremity as a result of hysteria or malingering. The three cases reported herewith demonstrate this condition and the three experiments confirm the clinical impressions.

CASE REPORTS

Case 1—A T, female, age 14, was admitted to Sheltering Arms Hospital, May 2, 1931, complaining of painful swelling of the left hand and forearm. She stated that eight months before she had cut a finger on a ring and that the swelling began around this laceration and extended over the hand and forearm (Fig 1). She had been under the care of a number of physicians, the treatment had been varied and included three incisions into the hand. None of these openings discharged pus. The swelling has continued without relief. She claims complete inability to move the hand and wrist. Her past personal history was unessential.

Physical Examination—The patient was well developed and well nourished. No abnormality was found except the swelling of the left hand and forearm, which were greatly increased in size, pitted on pressure, and the skin, particularly on the dorsum of the hand, appeared thin, red, and hot. The picture suggested acute inflammation. The blood count and uranalysis were normal. Roentgenologic examination of the bones of the hand and forearm failed to reveal any lesion.

Incisions of the hand was being seriously considered when one of my colleagues (Dr G. Paul LaRoque) suggested that the edema might result from the position and immobility of the part. In order to test this theory the patient was kept in bed with the hand elevated and fixed. In about 12 hours the edema had completely subsided and the hand appeared normal. She was then allowed to be up and in a short while the whole picture recurred. It was observed that she held the arm immobile in a dependent position and it might hold it downward over the side of the bed.

A more careful search was then made into her family history and it was ascertained that her mother had died when she was a small child. Her father had married again and there were several children by this second marriage. Her stepmother had always been kind and affectionate to the point of greater indulgence than to her own children, but this child had not been happy. Psychiatric consultants were positive in the diagnosis of major hysteria. She was kept under observation and treatment in the hospital for a number of weeks until she was entirely cured. Except for a few minor recurrences she has had no further trouble. She is now married, has children of her own, and is leading a normal life.

Case 2—C F, white, male, age 40, was admitted to the Church Home and Infirmary, Baltimore, Md., on the service of Dr. William F. Rienhoff, Jr., April 15, 1935.

The left hand and forearm were greatly swollen, red and tender (Fig 2). This condition had existed during the previous 18 months. He had had a similar illness several years previously, until he was cured by a medicine man of the Hopi Indians in Arizona. During the preceding few months he had been studied in clinics in other cities where a variety of diagnoses were made and a number of surgical procedures advised, including amputation of the arm. There was a history of an excellent background for hysteria. The arm and forearm were first held elevated in a plaster encasement and later by suspension. The edema gradually subsided entirely but the small joints of the fingers were permanently damaged by the long-standing immobility (Fig 3). He was kept in the hospital for a number of weeks and was finally persuaded that his disability had been entirely functional. At present there is no edema, but the mobility of the fingers has not been restored (Fig 5).

Case 3—This case is reported because it so closely resembles the others, but it has not been so adequately proved. The patient, an elderly Chinese beggar, was admitted to the Ellen Lavine Graham Hospital, in China, on the service of Dr. John H. Reed, Jr., complaining of swelling of the left hand and forearm which he stated followed a minor scratch of the skin many months previously.

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FIG. 2—Case 2 Condition of arm on admission to hospital



FIG. 3—Case 2 Condition of hand six weeks after admission to hospital

The swelling increased the size of the parts to at least twice that of the opposite side (Fig. 4). There were several clean, shallow areas of ulceration on the hand, but no evidence of acute infection. Several linear incisions were made over the forearm and fingers, from which a thin, clear fluid was discharged. After a short period in the hospital, the swelling almost completely subsided, there was no discharge of pus.



FIG. 4. Case 3. Condition of arm on admission to hospital.

SUMMARY—Two of these individuals were of the “neurotic” type with good backgrounds for hysterical manifestations. The third, a beggar, was a malingerer who used the self-produced deformity as an asset in his trade. It is interesting to note that the left hand was involved in all three. Their ages differed widely, two were males and one a female. All recovered without residual swelling, but the small joints of the hand in Case 2 were so damaged by the long-standing immobility that their function has not been restored.

EXPERIMENTAL DATA—In order to measure the changes in the normal forearm and hand resulting from the immobile, dependent position the following observations were made on each of three subjects. Measurements of diameters at fixed levels were made with calipers. Measurements of circumferences were made with a tape. Measurements of volumes of the hand, lower forearm, and upper forearm were made by immersing the part, to the same levels, at intervals of one-half hour, in a cylinder of water and determining the amount

of water displaced The results of these measurements are shown in Tables I and II

TABLE I

CHANGES IN MEASUREMENTS OF THE HAND AND FOREARM RESULTING FROM DEPENDENT, IMMOBILE POSITION FOR FOUR AND ONE-HALF HOURS

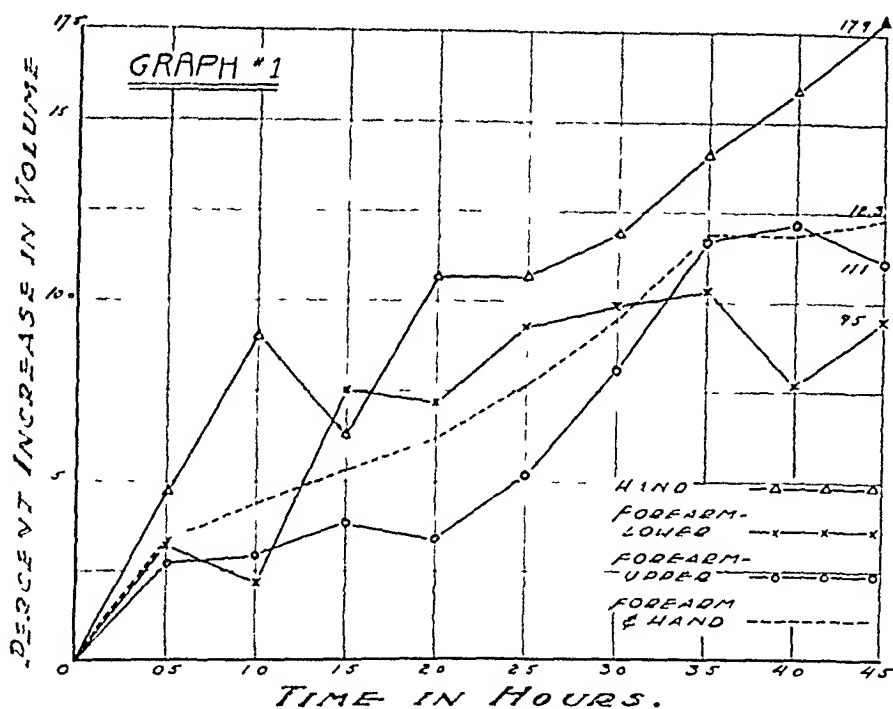
	Second Finger		Palm		Forearm	
	Diameter in Mm	Circumference in Mm	Diameter in Mm	Circumference in Mm	Diameter in Mm	Circumference in Mm
Case 2						
Beginning	19 0	62 5	30 0		65 0	244
End	22 0	71 0	36 5		73 5	247
Case 3						
Beginning	20 8	68 0	28 5		64 0	230
End	24 0	75 0	34 8		73 0	242

TABLE II

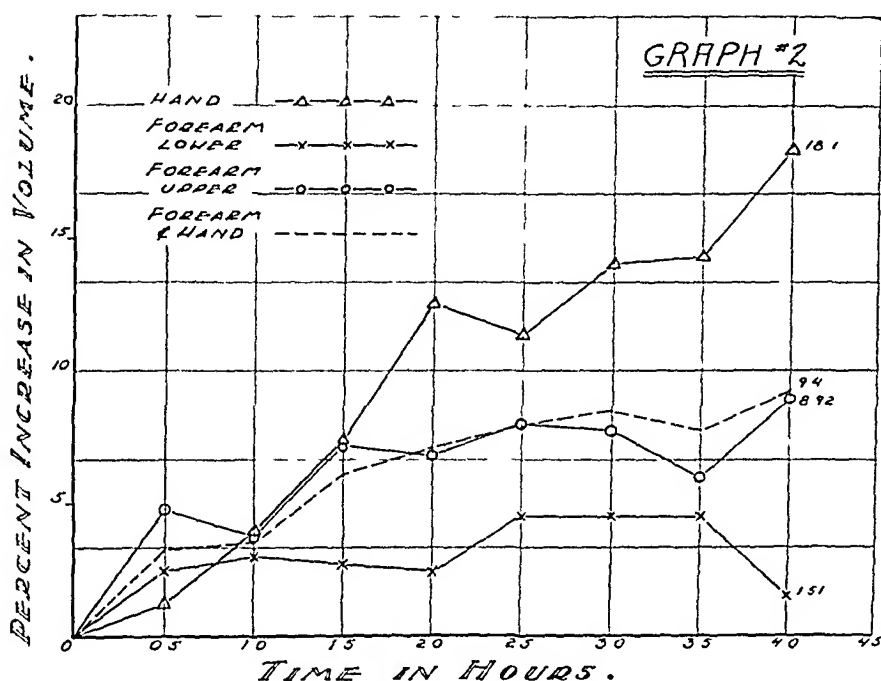
CHANGES IN VOLUME

	Hand		Lower Forearm		Upper Forearm		Total Volume of Hand and Forearm	
	Volume of Hand	Increase in Volume	Volume of Lower Forearm	Increase in Volume	Volume of Upper Forearm	Increase in Volume	Volume of Hand and Forearm	Increase in Volume
	Cc	Per Cent	Cc	Per Cent	Cc	Per Cent	Cc	Per Cent
Case 1								
Beginning	447		494		928		1,869	
End	527		541		1,031		2,099	
Increase in volume	80	17 9	47	9 5	103	11 1	230	12 3
Case 2								
Beginning	328		332		650		1,310	
End	388		337		708		1,433	
Increase in volume	60	18 1	5	1 5	58	8 9	123	9 4
Case 3								
Beginning	357		330		655		1,342	
End	425		323		719		1,467	
Increase in volume	68	19 0	-7	-2 1	64	9 8	125	9 3

A graphic presentation of the percentage of the increases in volume in Cases 1, 2 and 3 is shown in Graphs 1, 2 and 3



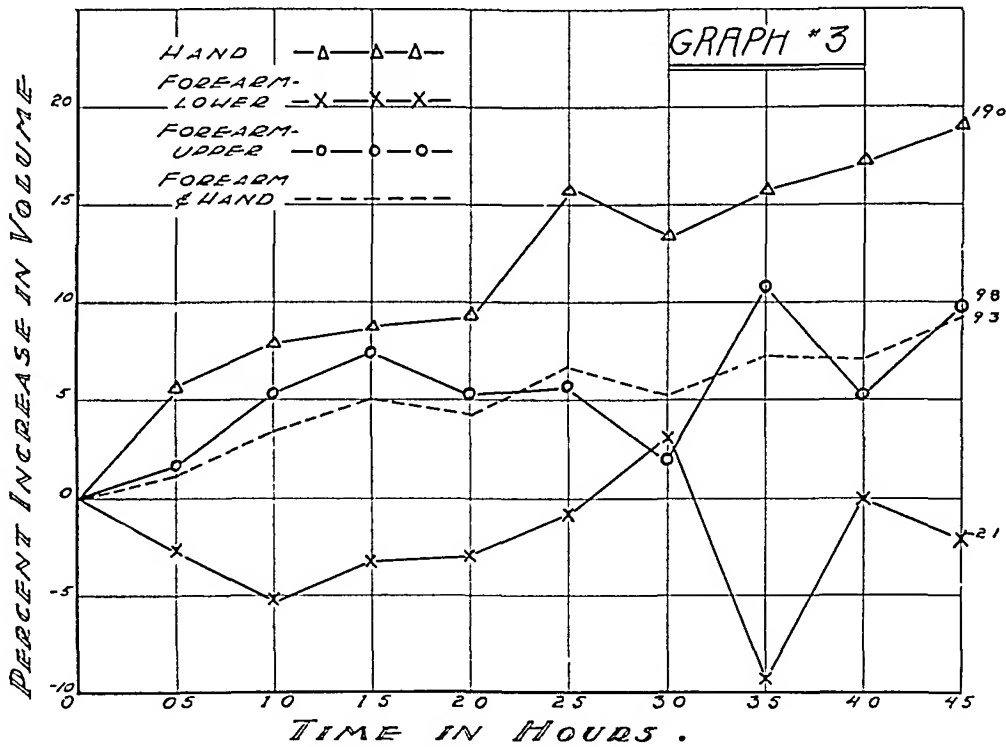
GRAPH 1—Case 1 Showing percentage of increase in volume



GRAPH 2—Case 2 Showing percentage of increase in volume

The results were uniform for the three subjects except the volume of the lower forearm which showed a substantial increase in volume (9.5 per cent)

in the first, a slight increase (15 per cent) in the second, and a decrease in the third (-21 per cent) All of the other measurements showed a steady increase in volume



GRAPH 3 —Case 3 Showing percentage of increase in volume

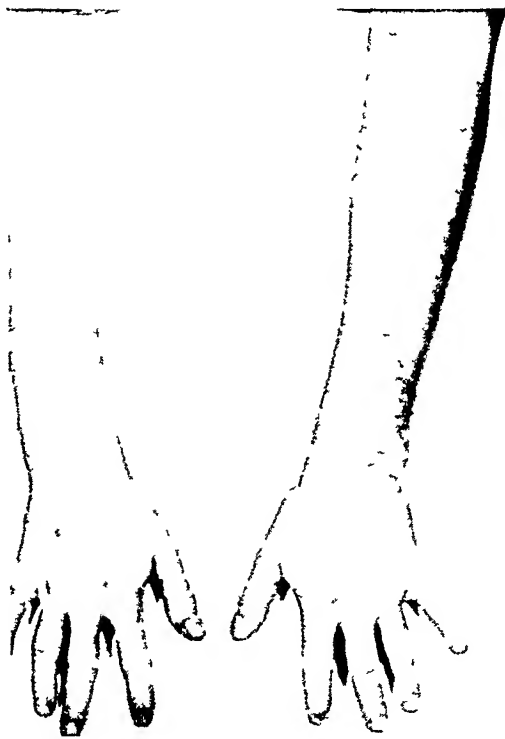


FIG 5—Experiment 2 Shows the appearance of the normal left arm after being four hours in a dependent immobile position

At the end of the first hour, a distinct enlargement of the dependent hand could be observed, and at the conclusion of the experiment it was quite marked (Fig 5) After concluding the experiments, each subject complained of some pain, numbness, and stiffness of the hand, but after using it normally for an hour, the edema subsided and normal sensation and mobility were restored

CONCLUSION

These three cases illustrate a unique manifestation of major hysteria which simulates surgical lesions That the edema resulted from the dependent, immobile posture of the arm was demonstrated by the prompt recovery of these patients by change of position with the addition of minor incisions in one The experiments further verify this conclusion

I am indebted to Doctors Reed and Rienhoff for permission to report their cases, and to Dr John L. Patterson, Jr., and Carrington Williams, Jr., for performing the experiments

REFERENCES

- ¹ Loeb, L. Edema. *Medicine*, **11**, 171, 1923
- ² Youmans, J. B., Wells, H. S., Donley, D., and Miller, D. G. Posture and Edema. *Jour Clin Invest*, **13**, 447, 1934
- ³ Youmans, J. B. Exchange of Fluid Between the Blood and Tissues. *Trans Assn Amer Phys*, **50**, 118, 1935
- ⁴ Wells, H. S., Youmans, J. B., and Miller, D. G., Jr. Tissue Pressure. *Jour Clin Invest*, **17**, 189, 1938
- ⁵ Landis, E. M., and Gibbon, J. H., Jr. The Effect of Temperature and of Tissue Pressure on the Movement of Fluid Through the Human Capillary Wall. *Jour Clin Invest*, **12**, 105, 1933
- ⁶ Parker, H. I. Hysterical Paralysis. *Med Clin North Amer*, **10**, 703, November, 1926

CAISSON DISEASE WITH SPECIAL REFERENCE TO THE BONES AND JOINTS*

REPORT OF TWO CASES

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AND

MOORE MOORE, JR., M D

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AMONG the unusual nonmalignant osseous lesions sometimes encountered are those produced by caisson disease. This condition has received but scant attention in medical literature. Not infrequently it has been discovered by accident in the course of radiographic examinations conducted for other purposes.

It seems worth while to the authors to point out the characteristic clinical and radiographic features of this process, and to emphasize the fact that it must be regarded as one of the causes of late arthritic changes which have an occupational basis.

Aristotle mentions a metallic vessel containing air when lowered into water, and records that the diving helmet was used as part of the equipment of Alexander the Great. At the Siege of Tyre (333 B C) divers removed obstructions and loosened anchors and cables. Julius Caesar describes a varnished leather apparatus for diving and both Roman and Greek navies employed divers.

Although Tiger, a French engineer, in 1839, was the first to successfully operate upon a case of caisson disease, men have been working in various capacities under increased air pressures either in caissons or diving suits since the sixteenth century. He, incidentally, was the first to note and emphasize the extremity pains which cause subjects to assume the characteristic attitude known as "bends." However, Paul Bert,¹ in 1871, was the first to describe such cases clinically and to advance the correct theory of their etiology.

Though this paper deals chiefly with the clinical and radiographic features of skeletal manifestations, a brief résumé of lesions by systems is included.

(1) Cerebrospinal. The symptoms range from numbness and tingling to unconsciousness and collapse. The special senses are frequently involved, Menière's symptom-complex being noted often.

(2) Cardiovascular. Manifested by embolism.

(3) Pulmonary involvement is shown by dyspnea (15 per cent of Erdman's cases). This is always a grave symptom for it is evidence of massive embolism, multiple in the lungs.

* Read at the Fifty-second Annual Meeting of the Southern Surgical Association Augusta, Ga., December 5, 6, 7, 1939.

(4) Visceral and Urogenital Symptoms are rare, nausea, vomiting and epigastric pain, however, also being grave signs indicative of massive embolism

(5) Skeletal System (osseous, connective, muscular and fatty tissues) Pain is the dominating symptom, occurring either alone or with other symptoms in from 85 to 90 per cent of the cases. The myalgias, ostalgias and arthralgias are described as "tearing, boring, gnawing or lancinating." Mild attacks are felt by almost all workers.

(6) Dermal Pruritis is very common and may be the first and only symptom. Lividity is associated with serious cases.

No actual figures as to the relative incidence of lesions according to systems are found except by Quadi,¹⁷ who states that the following, in decreasing order of frequency, has been his experience: (1) Muscular and articular forms (of sudden onset with rapid course and favorable prognosis). (2) Auricular. The lesions being in the internal ear. (3) Central nervous system. With lesions affecting locomotion. To these cases of sudden onset he also gives a good prognosis. All writers agree that dermal symptoms are most common for the incidence of the disease is almost 100 per cent, if trivial cases are counted.

It is well established that all symptoms and lesions are the result of actual bubble formation in the circulating blood or in various tissues. These are caused by the inability of the system to excrete rapidly enough via the lungs, the excess nitrogen which has been held in supersaturation in the various tissues under increased air pressure.

The blood is almost instantly saturated at the partial pressure of gas in the lungs. The kidneys (Hill and Greenwood¹⁸) saturate and desaturate ten times as rapidly as the body, as a whole, while the body becomes completely saturated in five hours (Haldane).

The absorptive power for nitrogen of fats and lipoids is five to six times greater than that of blood, and they, along with water, are the chief solvents of nitrogen. During the process of saturation, a large part of the nitrogen, absorbed by fat and lipoids, diffuses to them from body fluids. On decompression the reverse is thought to occur.

The tissues with poorest blood supply, in relation to nitrogen content, are the bone marrow and spinal cord. These tissues with high nitrogen content are enclosed in bone, thus preventing free diffusion of nitrogen into contiguous tissues and so making them dependent upon a comparatively poor blood supply for absorption and elimination. Consequently there is a retardation of nitrogen elimination from these tissues when bubbles are present in the blood, and when the pressure-head of nitrogen in the tissues is high such delay is apt to be prolonged.

In 1908, Boycott, Haldane and Damant⁶ showed that the only extravascular bubbles were those found between the fat cells of the cord and other areas rich in adipose tissue. No bubbles were ever noted in the cells them-

	Per Cent of Fat	Per Cent of H ₂ O	N ₂ Content (Cc /100 Gm)
Body as a whole	15.4	59.0	1.4
Brain	4.8	70.01	0.94
Spinal cord	27.8	70.01	2.2
Bone marrow	90.0		
Estimated = 1			

selves. It has been shown that nitrogen bubbles grow by accretion, and pressure in excess of the working level has been used to reduce the size of the bubble in recompression therapy, which accomplishes little in the way of removal since on rapid decompression the symptoms returned. In this instance helium may be used to displace nitrogen since it is inactive and has none of the toxic properties of oxygen. Naturally, the treatment is largely preventive, by slow decompression. Specific therapy of bones and joints will be discussed later.

Location of Bone and Joint Lesions and Their Relationship to Each Other—The long bones are the favored areas for both symptoms and lesions, possibly the vertebrae and membranous bones escape, due to the high proportion of red as compared to fatty marrow. Eidman⁸ reports about 70 per cent of symptoms in the lower extremities, chiefly the knees, the remainder being in the upper extremities. These figures agree with those of other writers. Also, he aspirated under water a few cubic centimeters of gas from under the periosteum of the tibia of two workers.

The location and severity of symptoms depend upon the site and volume of gas set free. Pain results when it is confined beneath any unyielding tissue (muscle spindles, ligaments, fascia, periosteum and nerve sheaths). Symptoms are rare in the liver, spleen, kidney, fat deposits of veins and these latter "silent" areas outnumber the "painful" ones which in turn outnumber the "vital" ones, i.e. the central nervous system. Symptoms have occurred during decompression, but are most common during the first few minutes after decompression. Eidman, in 3,692 cases, noted 50 per cent within 30 minutes, 95 per cent in three hours, but 1 per cent delayed over six hours. Four cases occurred between 15 and 23 hours. Reexposure after incomplete decompression is known to predispose to attacks, as is the use of alcohol shortly prior to exposure. Infarction from an old injury may determine the site at which a lesion locates.

Location of Lesions—German authors describe 11 cases, all of which present lesions involving a large joint. The hip is affected 12 times, the shoulder once. All cases, with two exceptions, are monarticular, these are both bilateral, in the hips. They all agree with Phemister, Kahlstrom and Burton¹³ that the pathology is a result of nutritional interference either from direct embolism in a main nutrient vessel or of pressure on the vessel wall by bubbles, or both. This sets up a train of infarction plus aseptic necrosis of

varying extent. Following this is the classic picture of gradual attempts at repair on the part of the bone by osteoclasia, creeping substitution and eventual delimitation by calcification as described elsewhere¹¹. Also, these German authors are of the opinion that the characteristic picture of alternating areas of translucency and density, with a secondary arthritis, is not the result of one exposure, but rather of repeated insults. All agree that the arthritis, which is of the deforming type, is a result of absorption, collapse and new bone formation in, or near, an epiphysis. Only one pathologic specimen was examined by them, and that only in the gross, the head of the femur and capsule being described as having many knobby excrescences. The German authors make no mention of extensive areas of aseptic necrosis extending far along the shafts of the long bones from the initial diaphyseal lesion. The vessels in this region have few anastomoses and are, therefore, easily clogged, which fact, probably, influences the location of the lesion.

Twynam,²⁵ in 1888, reported a case of a man who had severe symptoms of carson disease with pain and swelling above the right knee. Two months after the onset an abscess was drained there and later another one near the right major trochanter. Due to persistent sinuses, amputation, through the lower third of the femur, was performed two years later. The entire shaft of the femur was found to be necrotic and surrounded by an involucrum one-third of an inch thick. This seems to have been a case in which massive necrosis of the femoral shaft plus secondary infection produced a picture simulating pyogenic osteomyelitis.

Kahlstrom, Burton and Phemister¹¹ report four cases of long standing, one of which was proved by autopsy and one by biopsy. All were studied clinically and roentgenographically.

Molfino¹⁵ states that 27 of 30 cases had joint pains, mainly in the lower limbs and especially in the knees. He quotes the following descending order of frequency: Knee, shoulder, elbow, and hip. Motion, both active and passive, he states is not painful and articular pains persisted for only a few days. The long bones, especially the tibia, were found to be tender in the acute stage. Roentgenograms taken three to four days after onset showed no noteworthy changes.

Bassoe,¹ in 1913, reports 15 cases of which nine can be said to have definite bone or joint pathology demonstrable roentgenologically or clinically. The lesions were located as follows: Hip 6, knee 4, tibia 2, fibula 1, shoulder (humeral head) 1, ankle 1, talus 1. It is noteworthy that one case which had arthritis in both ankles and the right knee had only the one exposure after working under a maximum pressure of 26 pounds. The talus lesion showed a mushrooming of this bone into the navicular with stiffening of the ankle, as well as islands of sclerosis and atrophy in the tibia, but also had evidence of residual cord disease, thus giving rise to the question of trophic osteo-arthropathy.

No authors report pathologic fracture, except perhaps Bassoe, who de-

scribes a case which had a spontaneous patellar fracture 11 years after "the bends". Roentgenograms showed osteoporosis and atrophy of the fragments at the time, but healing was not unusual. This patient also had permanent cord damage due to the disease.

The specific therapy of bone and joint lesions is, naturally, that of prevention and correction of deformity from contracture at the affected joints. In the event of severe deforming arthritis, arthrodesis and arthroplasty must each be considered in relation to the individual case.

The importance of recognition of both clinical and roentgenologic features of this disease, with its intimate relationship to possible compensation claims, is self-evident. There is one case recorded of arthritis deformans of the hip as an alleged result of caisson disease in which causal relationship was not established and compensation was denied (Jaeger¹²). This, aside from purely legal aspects, apparently was adjudged chiefly on the grounds that it was an occupational disease and did not occur as the result of one attack. Also, the first signs were noted three years after the exposure and came on intermittently. No roentgenograms of the long bones were published and they were thought to be consistent with early deforming arthritis, although one expert considered it to be caisson disease.

Roentgenographically, caisson disease may be distinguished by multiple distribution in the medullary portion of the bone, rarely, if ever, producing cortical change. The shaft is not expanded and the infarction presents as an area of irregularly increased density usually surrounded by a thin band of calcification on the outside of which is a variable amount of normal appearing medulla. The lesion is located in the diaphysis and may, or may not, involve the epiphysis and secondarily the joint. Articular changes resemble arthritis deformans. The lesions almost always are located in the large long bones, namely, the femur, tibia and humerus and more often in the lower than in the upper extremity.

The diseases most likely to be confused in diagnosis are (1) Chronic sclerosing osteitis which is not usually multiple and in which there is evidence of cortical thickening and narrowing of the medullary cavity. (2) Low grade sclerosing osteogenic sarcoma in which there is definite pain far in excess of that in caisson disease, and the area of involvement fades by insensible gradations to normal tissue, also, there is no sharply delimited calcific boundary. (3) Calcifying enchondroma which, although frequently multiple and symmetric, is usually expansile and does not involve the joints. (4) Lues can be differentiated by periosteal reaction and serologic tests. (5) Tuberculous diaphysitis usually shows laminated new bone along the shaft and does not have the irregular outline plus the peripheral band of calcification, it also is not multiple, and supporting stigmata may be found elsewhere in the body. A history of exposure to compressed air can be elicited always, and this is the deciding point.

The roentgenographic picture is easily explained by the pathology. This has been shown¹¹ to consist of a central area of dead bone whose irregular outline is due to partial replacement by new bone and new marrow. When the replacement process ceases the region is bounded by a band of calcification. Small areas can be replaced entirely by dense new bone. Joint changes are dependent upon the same process plus the added factor of weight bearing in many instances.

Thus the entire picture may be explained on the basis of vascular insufficiency and nutritional disturbance in the late stages.

CASE REPORTS

Case 1—M. H., male, white, age 57, was a compressed air worker who was first treated at the Memorial Hospital, July, 1938, for a squamous carcinoma of the tongue. The patient had worked as a "sand hog" for about 16 years, during which time he had many trivial and at least eight definitely recognizable attacks of the "bends." The first attack was about 1904, the last in 1918. In November, 1914, while working on the Colorado River Irrigation project, at 38 pounds' pressure and in intense heat (to about 130° F.), the patient suffered his most severe attack immediately after coming up from the decompression terminal. At this time workers alternated one hour of rest after each hour of labor for a total of eight hours. The patient suffered collapse and unconsciousness, which were of short duration. He experienced aphasia for two days and loss of urinary sphincter control for three to four days, but no loss of rectal sphincter control. No visual or auditory symptoms were noted, but he did have a complete right hemiplegia, lasting 13 to 14 days. His recovery was rapid and he returned to work three weeks after the incident, able to do a full day's work. During his convalescence he had marked muscle and joint pains referable to the right upper and lower extremities.

He also had an attack in 1918 in New York Bay, at which time the abdominal wall became discolored but there were no other remarkable symptoms. In all attacks pain was referable especially to the right hip and shoulder. There was never any joint swelling or discoloration. After the 1914 incident, patient noted a gradual stiffness of the right hip and shoulder, being definitely noticeable in a few months' time. He had pain of a dull nature, which was somewhat aggravated by raw weather though it had been less in the past two to three years. The left knee had had milder similar pains.

Physical Examination—The right hip is almost completely ankylosed in about 10° flexion and 10° adduction.

Measurements	Right	Left
Ant sup spine to internal malleolus	86.0 cm	92.5 cm
Tibial tubercle to internal malleolus	34.5 cm	34.5 cm
Thigh circumference (20 cm above tibial tubercle)	37.5 cm	40.5 cm

The patient stands with a marked elevation of the right pelvis and a compensatory lumbosacral scoliosis. Patient walks with a definite right hip limp.

Right upper extremity External rotation is nil. Internal rotation about one-half normal. Glenohumeral abduction to 35°, combined with scapular motion and anterior elevation to 75°. Patient can just put his hand on the iliac crest and comb his hair. There is some crepitus in the shoulder with motion, but no pain.

Neurologic Findings	Right	Left
Knee jerks	Two plus	Three plus
Ankle jerks	One plus	Two plus
Biceps (humeri)	One plus	Two plus



FIG 1—Case 1 Showing a characteristic medullary fracture in the right femur



FIG 2—Case 1 Showing the tibial lesion



FIG 3—Case 1 Showing the arthritis deformans—note the osteophytes



FIG 4—Case 1 Showing the arthritis deformans of the right hip with almost complete fusion

There is a left Horner's syndrome

Roentgenographically, the patient presented lesions in the following areas

- (1) Right lower femoral diaphysis (Fig 1)
- (2) Right upper tibial diaphysis (Fig 2)
- (3) Right shoulder and humeral head (Fig 3)
- (4) Right hip and femoral head (Fig 4)
- (5) Left lower femoral shaft
- (6) Left humeral head (small)

Other than the right hip and shoulder, the lesions were clinically "silent"



FIG 5—Case 2 Showing both a productive arthritis of the right shoulder joint and extensive diaphyseal lesions of the humerus

Case 2—W R, Negro, male, age 49, was first seen in the Memorial Hospital, December, 1938, at which time he was referred to us for treatment of bronchiogenic carcinoma, arising from the right main bronchus. A routine roentgenogram of the chest included a portion of the right humerus, which showed a huge infarct in the shaft of the bone, and views of the humerus itself were then obtained, but at that time we were unable to diagnose the lesion. On being questioned, at a later date, the patient gave the following history. In 1930, patient worked as a "sand hog" on the Erie Tunnel project, working in pressures up to 40 pounds. He was thus employed for about four months, and this was his only connection with compressed air work. About two to three days after commencing it he had had a very trivial attack, noting some soreness and mild pain with slight subsequent stiffness referred solely to the shoulders and arms. About two

weeks later he came up from the decompression terminal, after working at 30 pounds' pressure, complaining of severe pains, particularly in his shoulders and both entire upper extremities. There was pain in the lower extremities to a lesser degree, chiefly the knees. He did not lose consciousness or become paralyzed. Within 20 minutes, after the onset, he was replaced in compressed air and the pain was slowly alleviated, requiring about eight hours. There were no central nervous system symptoms whatsoever. Following this attack there was extensive stiffness and soreness of both upper and lower extremities, the former locale being more noticeable. However, he continued to work under varying pressures with a steady diminution of symptoms, all disappearing in two to three weeks. He then noted a gradual loss of the normal mobility of right shoulder, but had no joint pains there. The patient suffered no other attacks of the "bends." In January, 1939, he experienced a moderately acute attack of arthritis in his left wrist. Again, in May, 1939, he had a similar episode affecting the left shoulder. Both responded to symptomatic treatment and in neither was an etiologic agent determined, or significant roentgenologic changes noted.

Physical Examination—Ankles, knees and hips normal. Right shoulder. Atrophy of soft parts of the girdle. Internal rotation about 10° – 15° . External rotation 0° – 5° . Glenohumeral abduction to 40° , combined with scapular motion and anterior elevation this increases to 75° . He can just put his hand on the iliac crest. Right elbow and wrist negative. No reflex changes noted.

Roentgenographically, this patient showed lesions in the following regions:

- (1) Right humeral shaft and shoulder (Fig. 5)
- (2) Left lower femoral shaft
- (3) Left upper humeral shaft (small)
- (4) Left upper tibial diaphysis (small)
- (5) Right upper tibial diaphysis
- (6) Both ischia (small)

The lesion in the right shoulder was the only one giving clinical signs.

SUMMARY

The available literature referable to caisson disease, particularly as exhibited in the skeletal system, has been reviewed.

It seems quite likely that the characteristic lesions can result from one insult of sufficient severity.

The late effects of nitrogen gas bubble formation in the tissues and circulation form a recognizable picture, both clinically and roentgenographically, the importance of which, in the field of compensation claims, has been pointed out.

Two cases have been presented. Each of these has lesions which are clinically silent in addition to the evident arthritis.

Attention is called to caisson disease as a possible cause of vague bone and joint pains which may be discovered later as "silent" areas of aseptic necrosis.

BIBLIOGRAPHY

- ¹ Bassoe, P. Late Manifestations of Compressed Air Disease. *Am Jour Med Sci*, **145**, 526, March, 1913.
- ² Behnke, A. R. Application of Measurements of Nitrogen Elimination to Problem of Decompressing Divers. *U. S. Nav. Med. Bull.*, **35**, 219, April, 1937.
- ³ Behnke, A. R., and Shaw, L. A. The Use of Oxygen in Treatment of Caisson Disease. *U. S. Nav. Med. Bull.*, **35**, 61, January, 1937.
- ⁴ Bert, P. *La Pression Barometrique*, Paris, 1878.

- ⁵ Bornstein, A, and Plate Uber chronische Gelenkveränderungen, entstanden durch Pressluftekrankung Fortschr ad Geb d Rontgenstrahlen (Hamburg), 18, 197-207, 1911-1912
- ⁶ Boycott, Damant, and Haldane The Prevention of Compressed Air Illness Jour Hyg, 8, No 3, June, 1908
- ⁷ Christ, A Study of Caisson Disease and Typical Form of Disease of Hip Joint Deutsch Ztschr f Chir, 243, 132, 1934
- ⁸ Erdman, S The Acute Effects of Caisson Disease Am Jour Med Sci, 145, 520, April, 1913
- ⁹ Frank, H Caisson Disease of Hip Joints Munchen Med Wchnschr, 82, 457, March 21, 1935
- ¹⁰ Hill, L Caisson Sickness London, 1912
- ¹¹ Hodges, P C, Phemister, D B, and Brunschwig, A The Roentgen Ray Diagnosis of Diseases of the Bones and Joints Thos Nelson and Sons, 1938
- ¹² Jaeger, F Arthritis Deformans of Hip Joint as Alleged Result—Causative Relation Not Established—Compensation Denied Monatschr f Unfallhr, 44, 374, July, 1937
- ¹³ Kahlstrom, S C, Burton, C C, and Phemister, D B Aseptic Necrosis of Bone Surg, Gynec and Obstet, 68, 129-146, February 1, 1939
- ¹⁴ Keays, F L Compressed Air Illness with a Report of 3,692 Cases New York City, 1909 Med Dept Pub, Cornell Univ Med Coll
- ¹⁵ Molino, F Arthralgic Form of Caisson Disease Rassegna di med appl lavoro indust, 8, 92-98, April, 1937
- ¹⁶ Plate, E Arthritis Deformans of Hip (Case) Arch f Orthop, 26, 201, 1928
- ¹⁷ Quidri, U Caisson Disease with Report of 41 Cases Cervello, 16, 275-300, September 15, 1937
- ¹⁸ Sayers and Yant The Value of Helium and Oxygen in Diving Anesth and Analg, 5, 127, June, 1926
- ¹⁹ Seifert, E Rare Disease of Hip Joint Zentralbl f Chir, 63, 2318, September 26, 1936
- ²⁰ Shaw, L A Physiologic Effects of High Pressures Jour Indust Hyg and Toxicol, 18, 486, October, 1936
- ²¹ Shilling, C W Caisson Disease and Its Relation to Tissue Saturation with Nitrogen U S Nav Med Bull, 33, 434, October, 1935
- ²² Shilling, C W Compressed Air Illness Review of Literature U S Nav Med Bull, 36, 9, January, 1938
- ²³ Shilling, C W Symptoms of Compressed Air Illness U S Nav Med Bull, 36, 235, April, 1938
- ²⁴ Singstad, O Industrial Operations in Compressed Air Jour Indust Hyg and Toxicol, 18, 497-523, October, 1936
- ²⁵ Twynam, E G A Case of Caisson Disease Prince Alfred Hosp, Sydney, N S W Brit Med Jour, 1, 190-191, January, 1888
- ²⁶ Vernon Solubility of Air in Fats and Its Relation to Caisson Disease Proc Roy Soc, 79, B 21, 1907

DISCUSSION—DR ISIDORE COHN (New Orleans, La) While I have seen none of these cases, we can never tell when some of these people who have been working on construction projects of this kind might happen to come our way, and I am sure in this case I might have thought of Gaïie's disease. In one of these cases the lateral view of the tibia would have made me think of the sclerosing type of osteitis. In both shoulders I noted an absorption of the neck with the production of what would correspond to a coxa vara of the hip. I am amply repaid for staying over to see these pictures and hear Doctor Coley.

DR BRADLEY L COLEY (New York, N Y, in closing) In answer to Doctor Cohn's question, I would say that I think the bony deformity he mentioned in the upper humerus is also present, to a certain extent, in the views of both hips of the first patient. It is apparently due to a gradual softening during the period when the infarcted area of bone is becoming calcified.

It seems to me that with conditions as unsettled as they are to-day, and with submarine and other types of warfare so general, it is not beyond the realm of possibility that some of us may encounter more of these cases as time goes on, particularly if—as it now seems most unlikely—this country eventually becomes involved in another World War.

A MODIFIED SPUR-CRUSHING CLAMP AND ITS USE*

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THOMASVILLE, GA

It is generally agreed that the exteriorization type of operation in some form, for resection of the left colon and upper sigmoid, carries with it the minimum of risk. The procedure commonly known as the Mikulicz multiple-stage resection has a rather limited field but in a modified form permits just as radical removal as any other operation. Exteriorization resections, such as that described by Rankin¹ and known as the "obstructive resection," have greatly extended the field of this procedure without increasing the risk to any appreciable extent. However, there are several objectionable features, acquired at the price of safety, which, if reduced to a minimum, should give still broader scope to this excellent procedure.

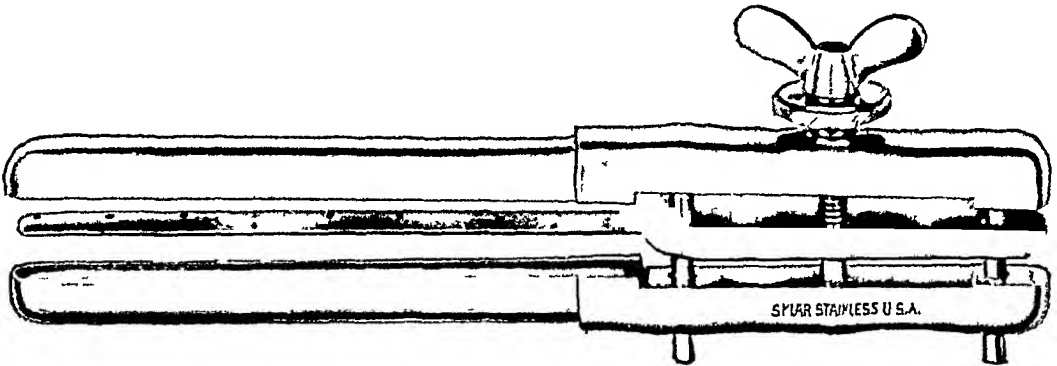


FIG. 1.—The Stetten spur crusher

It is not the purpose of this presentation to enter into a discussion of the advantages or disadvantages of any operation but to call your attention to the writer's modification of a spur-crushing clamp which, for him at least, has eliminated some of the objectionable features of the exteriorization type of resection referred to above.

These objectionable features may be briefly listed as (1) Long convalescence due to multiple stages, (2) a colostomy with its accompanying disagreeable features, (3) repeated applications of the spur-crushing clamp often associated with pain, nausea and vomiting, (4) the risk of clamping beyond the desired area and the associated danger of injury to small bowel, and (5) the difficulty in closing the colostomy in a small percentage of cases.

The writer recently directed a brief questionnaire to a small group of surgeons known to be especially interested in surgery of the colon. The object of this questionnaire was to find out whether or not these men, in their extensive experience, had encountered the same difficulties the writer had

* Read before the Fifty-second Annual Meeting of the Southern Surgical Association, Augusta, Ga., December 5, 6, 7, 1939.

with the exteriorization operation, in his more limited experience. There was a certain degree of satisfaction obtained in learning that they, too, found it necessary, as a rule, to make at least two, and often three, applications of the spur clamp, and that in a certain percentage of their cases the colostomy failed to heal completely after the first attempt at closure. All were of the opinion that such failure is usually due to insufficient destruction of the spur.

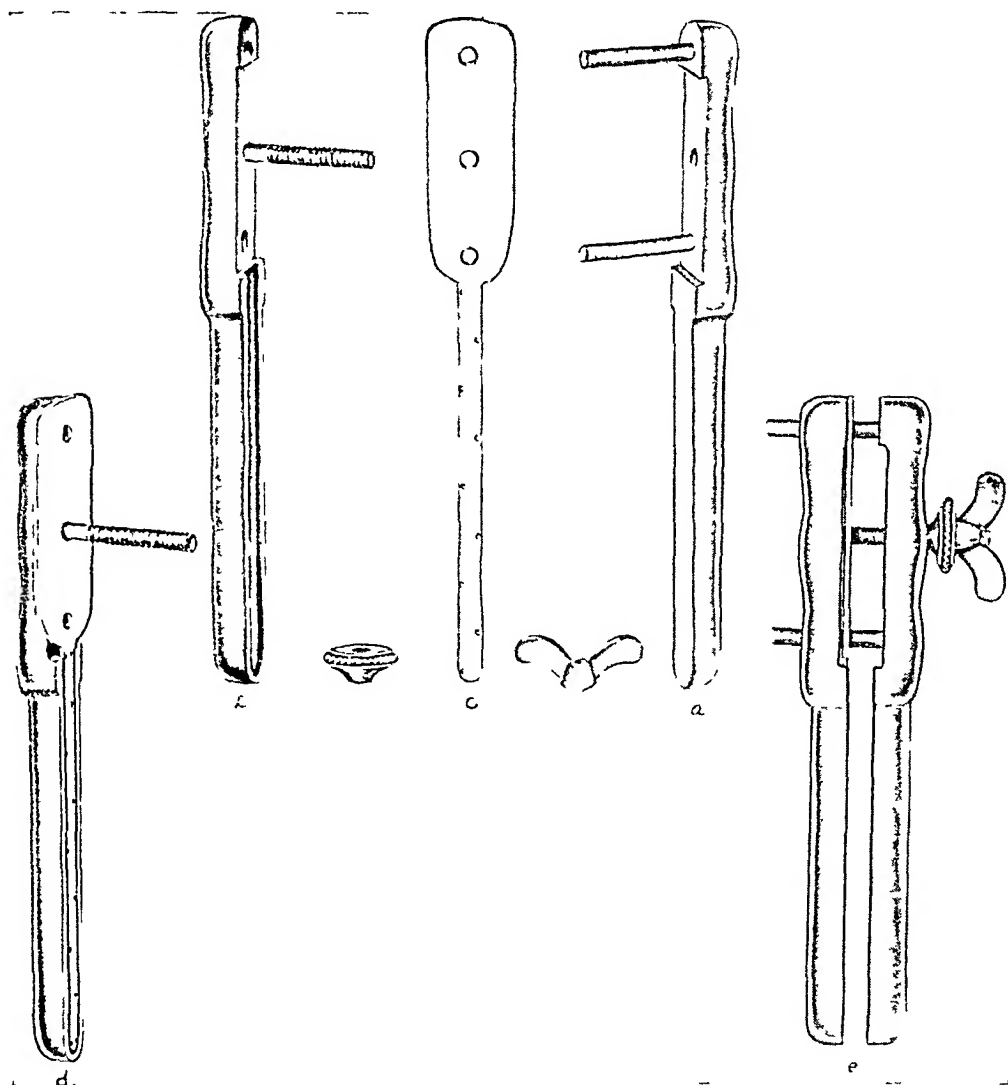


FIG 2—The author's modification of the Stetten clamp. Detailed description of this clamp will be found in the text.

This repeated application of the clamp, with its accompanying discomfort, which may be followed by failure of the colostomy to heal after operative closure, is likely to be very disheartening to an already discouraged patient.

Any clamp or improvement in technic that will permit one to obtain a sufficient cut through the septum with one application and at the same time insure the safety of the adjacent small bowel will reduce both the discomfort and the hazards of the operation and shorten the period of convalescence.

In performing the exteriorization operation, most surgeons prefer to suture the two ends of the severed bowel together for a distance of four or five inches to lessen the chance of clamping adjacent small bowel. However,

as pointed out by Jackson¹ before this Association last year, a five-inch suture line on the bowel may shrink to less than three within a short while. An attempt, therefore, to cut the spur to the approximate depth of the area sutured may result in the jaws of the clamp biting beyond this area and injuring adjacent bowel.

Edema and induration at the site of the resection usually make it diffi-

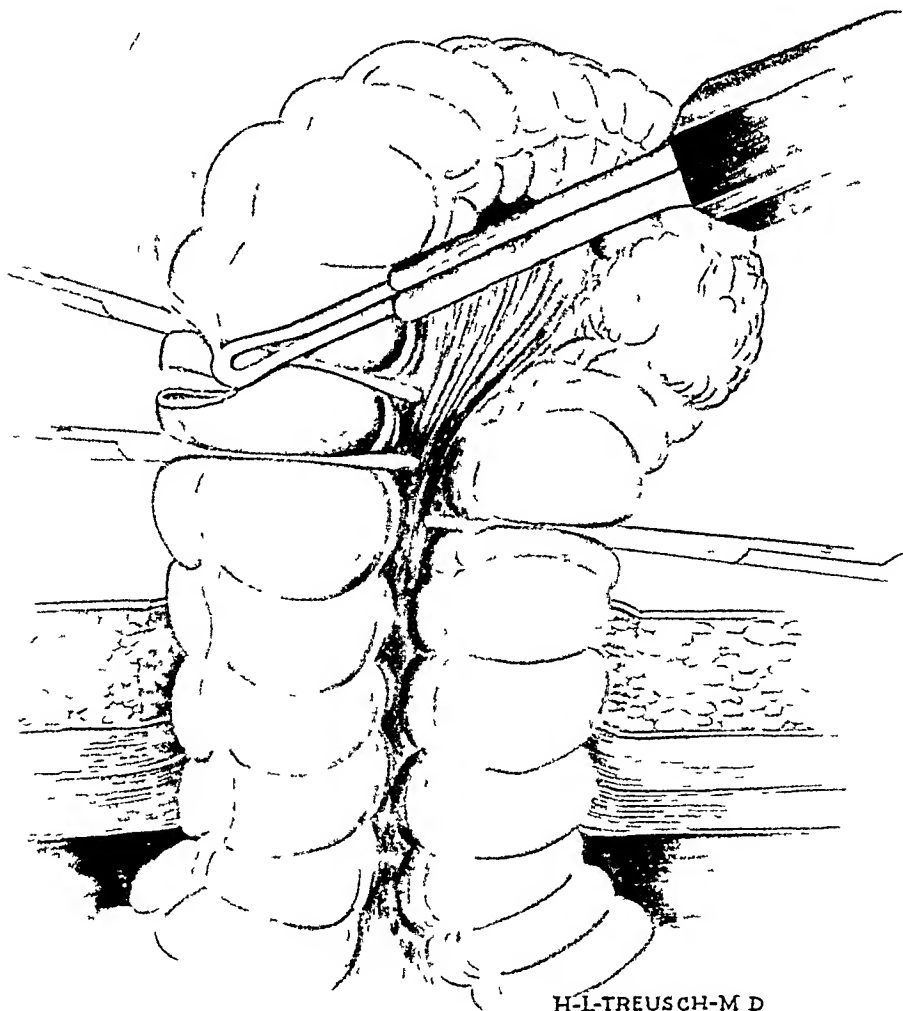


FIG. 3.—Showing removal of the section of the bowel containing the growth, along with the mesentery and nodes.

cult to apply a clamp for any depth until such reaction has subsided. Because of this some surgeons prefer to wait several weeks before attempting to cut the septum. This means a delay in the ultimate closure of the colostomy and prolongs convalescence.

The clamp the writer wishes to call to your attention permits the operator to accurately determine the location and depth of the opening to be made in the septum with one application and insures against injury to adjacent bowel. The crushing force may be applied the moment the obstructing clamps are removed or at any time thereafter.

Description of Clamp—The clamp is a modification of the Stetten spur-crusher (Fig 1) This clamp is in common use to-day and need not be described One advantage of this style clamp is that it produces equal pressure throughout the entire crushing surface at all times

In the writer's modification of this clamp the jaws are slightly wider and are four inches long (Fig 2) Instead of grooves on the crushing surface,

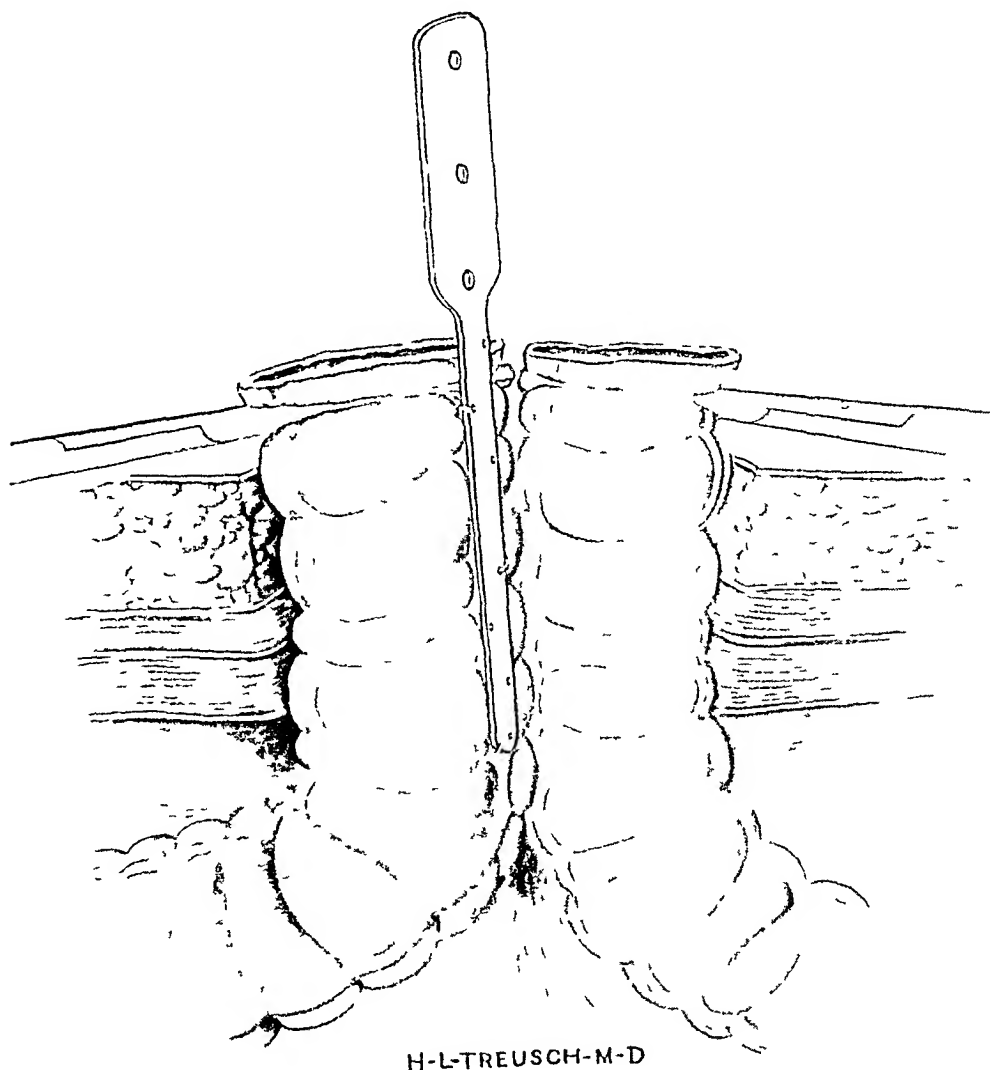
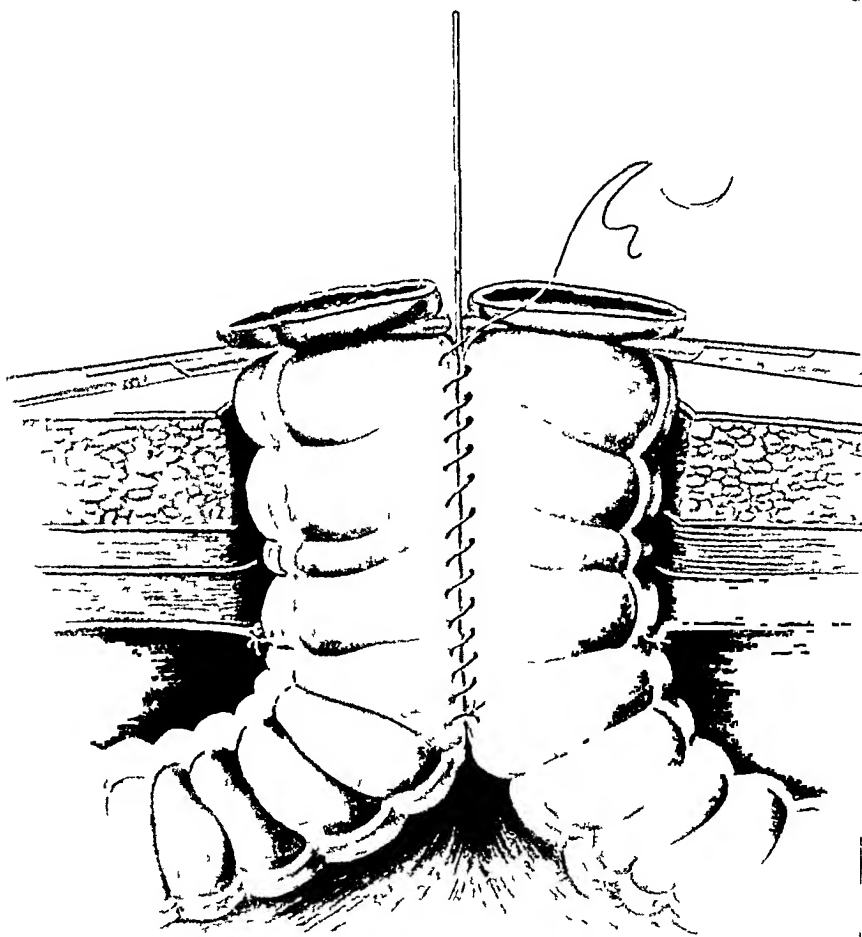


FIG 4—Showing the first step in applying the clamp. The tongue has been anchored to the longitudinal band of one end of the severed bowel by three silk sutures. Note that these are not all placed on the same side of the tongue, thus preventing rotation. The mesentery has been rotated laterally.

one jaw, called the upper jaw (Fig 2 a) for identification purposes, is perfectly smooth, while the other, called the lower jaw (Fig 2 b), is hollowed out to receive the third part, called the tongue (Fig 2 c), leaving a narrow crushing surface, or rim, around the groove.

This third part, or tongue, rather resembles a spatula with a blade and handle. The blade is made so that it fits loosely in the groove in the lower jaw (Fig 2 d), and staggered every half inch along its edges are small perforations or suture holes. The handle contains three holes that fit over the posts on the jaw handles when the clamp is assembled (Fig 2 e).

Method of Using Clamp—The portion of bowel containing the area to be resected is delivered and excised, along with its mesentery and nodes, between crushing clamps (Fig 3). The two ends of the cut bowel are then brought together in the usual way for a distance of three or four inches, if possible. But, instead of suturing these together at this point as is usually done, the tongue part of the clamp is sutured to one of the bowel ends, prefer-



H-L-TREUSCH-M-D

FIG 5—Showing the mesial side of the bowel ends sutured together with a continuous suture of fine chromic catgut—burying the blade of the tongue like a finger in a glove. An atraumatic needle is usually used instead of the large eye shown here by the artist. The peritoneum is shown stitched to the bowel.

ably along a longitudinal band, by three or four interrupted, fine silk sutures (Fig 4). This blade is so placed that its tip will be at the base of the future septum or spur. After the blade of the tongue has been anchored in this manner, the two ends of the bowel are sutured together (Fig 5) in the usual way, with a continuous suture of fine chromic catgut, so that the blade is buried between the bowel walls like a finger in a glove. If the bowel has been rotated mesially, as suggested by McNeely and Lichtenstein,² with the mesentery laterally, it is only necessary to suture the bowel ends together on the mesial side of the blade and around the tip. The remaining steps in

this stage of the operation consist in the usual suturing of the peritoneum around the two bowel ends and loosely closing the wound edges, leaving the bowel ends, occluded by the crushing clamps, protruding from the wound with the handle of the tongue rising between them like a periscope

At the end of 48 or 72 hours, depending upon the patient's condition and comfort, both obstructing clamps are removed and the jaws of the crushing

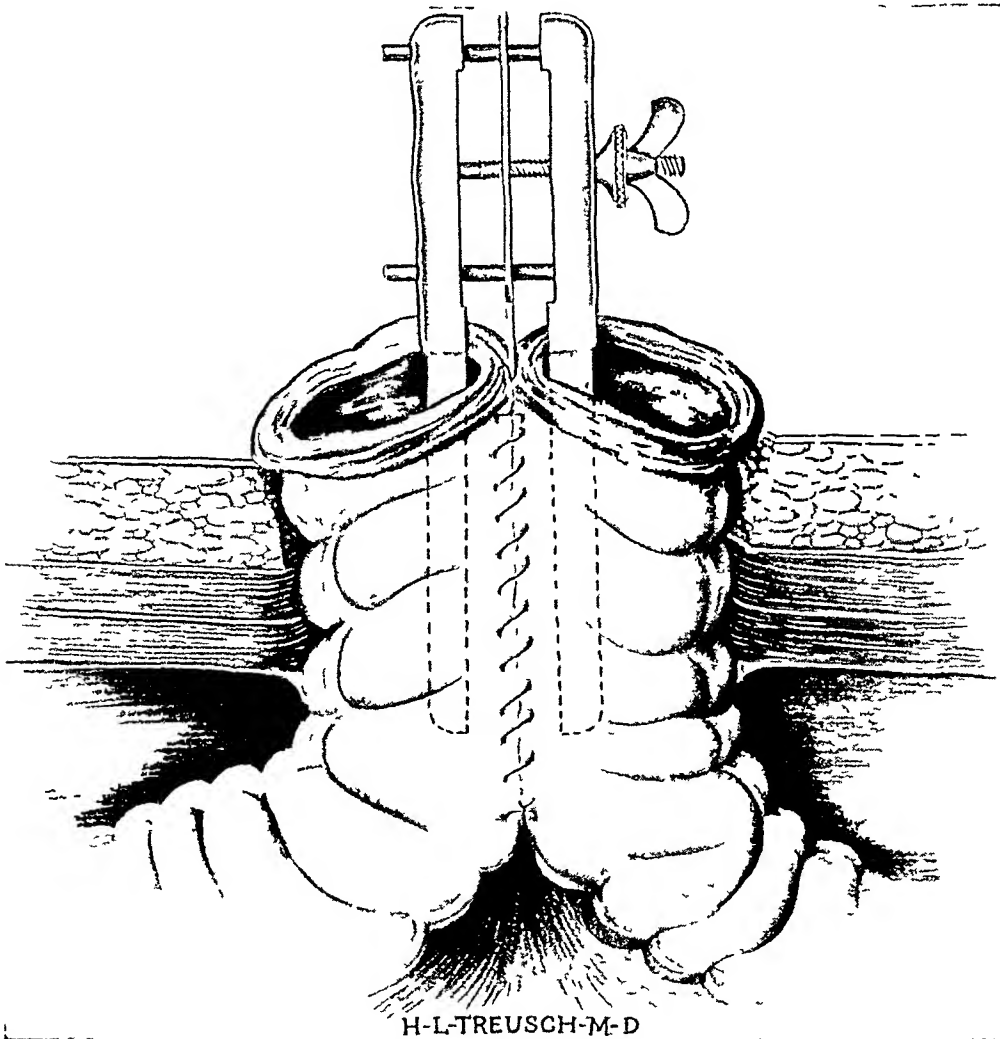


FIG 6—Both obstructing clamps have been removed, the bowel ends opened, and the jaws of the crushing clamp have been fitted to the blade ready for the crushing force to be applied by screwing down the wing nut

clamp are applied at once, one in the ascending and the other in the descending arm of the double-barrel colostomy (Fig 6) It is not necessary, as a rule, to feel with the finger within the bowel ends for the spur before inserting the jaws The tongue or guide shows the way and has kept the bowel "ironed out" When the posts of the jaws fit in the holes on the tongue handle there can be no question as to where the jaws are One may be sure (1) That no stray loop of bowel has gotten in between the jaws of the crushing clamp, (2) that the septum will maintain its original length, because it has been kept "ironed out" by the tongue blade, and (3) that one application of the clamp will crush the spur as far down as the tongue blade is sutured, namely, to the base of the spur

As soon as the clamp is fitted, pressure is exerted by screwing down on the wing-nut. This is done several times each day and is usually painless. The entire clamp with the necrotic portion from the septum usually comes away on the sixth or seventh day. By this time the edema of the bowel ends has greatly subsided and one may attempt closure of the colostomy at this time with a reasonable assurance of its remaining closed. However, the removal

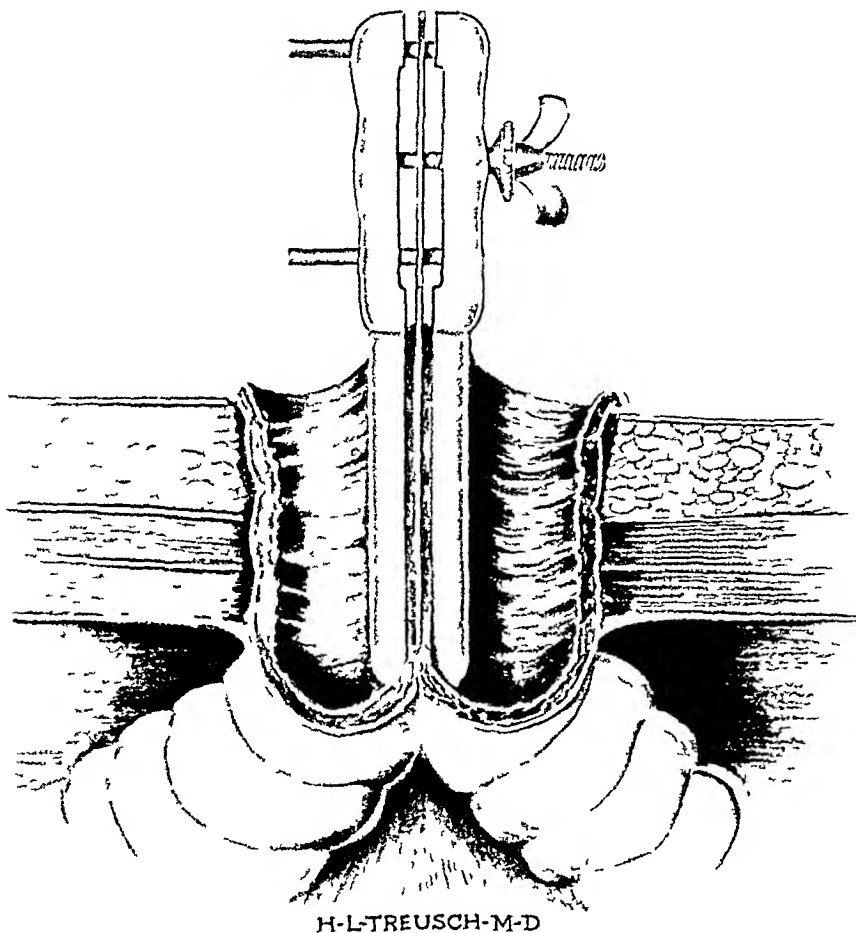


FIG. 7—The mesial sides of the bowel ends have been removed by the artist to show the relationship between the bowel walls and the different units of the clamp.

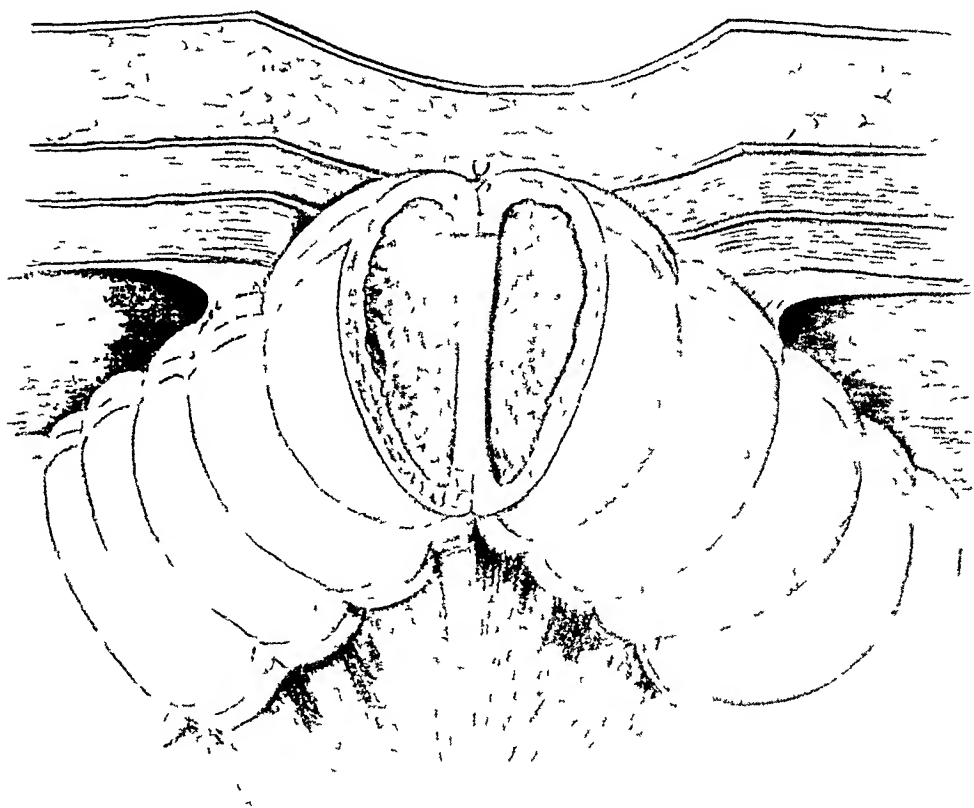
of the clamp is usually the beginning of a through passage of bowel contents soon to be followed by normal bowel movements and lessening of the colostomy drainage. Since both of these are encouraging to the patients, we usually allow them to leave the hospital after ten days or two weeks.

Some of these cases would no doubt heal without further surgery, but unless there is some contraindication, we prefer to have them return after two weeks for an extraperitoneal closure, in order to eliminate a possible hernia. With a deep, wide opening in the septum, flush with the bowel floor, the closure of the colostomy transversely is relatively simple and should be followed by very few failures.

Two theoretic objections have been raised to the employment of this tongue,

namely (1) The additional sutures increase the risk of infection, and (2) the blade tends to allow drainage from the bowel to seep down between the approximated surfaces

Naturally, care should be exerted in introducing all sutures into the bowel wall. The sutures anchoring the tongue are shut off from the general peritoneal cavity by the running suture commonly used, and by applying the clamp as soon as the obstructing clamps are removed there is no chance for the bowel contents to enter the pocket containing the tongue-blade.



H-L-TREUSCH-M-D

FIG 8—Extraperitoneal closure of the colostomy. Suture line transversely

REFERENCES

- ¹ Jackson, Reginald H. Technic and Demonstrable Advantages of Devine Colostomy. *ANNALS OF SURGERY*, 110, No 1, 14-24, July, 1939
- ² McNeely, R. W., and Lichtenstein, Manuel E. The Mikulicz Operation—Development and Technique. *Surg, Gynec and Obstet*, 69, No 3, 327, September, 1939
- ³ Rankin, Fred. *Practice of Surgery*. Dean Lewis, 7, Chap 4, 100

BOOKS RECEIVED

THE 1939 YEAR BOOK OF NEUROLOGY, PSYCHIATRY AND ENDOCRINOLOGY Edited by Hans H Reese, M D, Nolan D C Lewis, M D, and Elmer L Severinghaus, M D
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Chicago The Year Book Publishers, Inc, 1939

TRANSACTIONS OF THE AMERICAN SURGICAL ASSOCIATION Edited by Walter E Lee, M D Vol LVII, Philadelphia, J B Lippincott Co, 1939

HANDBOOK OF ORTHOPAEDIC SURGERY By Alfred R Skands, Jr, M D, and Richard B Rancu St Louis C V Mosby Co, 1940

THE MACLEWIN OUTLOOK IN SURGERY By Professor G Grey Turner, D Ch, M S, F ACS FRACS Glasgow Jackson, Son and Co, 1939

MANUAL OF FRACTURES, DISLOCATIONS AND EPIPHYSEAL SEPARATIONS By Harry C W S de Brun Chicago The Year Book Publishers Inc, 1939

ARTIFICIAL PNEUMOTHORAX Edited by Edward N Packard, M D, John N Hayes, M D, and Sidney F Blanchet M D Philadelphia Lea and Febiger, 1940

TREATMENT OF WAR WOUNDS AND FRACTURES By J Trueta, M D New York Paul B Hoeber, Inc, 1940

SHALL WE LIVE ON By W A Newman Dorland, M D New York Fortune's 1940

EDITORIAL ADDRESS

Original typed manuscripts and illustrations submitted to this Journal should be forwarded prepaid, at the author's risk, to the Chairman of the Editorial Board of the ANNALS OF SURGERY

Walter Estell Lee, M D
1833 Pine Street, Philadelphia, Pa

Contributions in a foreign language when accepted will be translated and published in English

Exchanges and Books for Review should be sent to James T Pilcher, M D, Managing Editor, 121 Gates Avenue, Brooklyn, N Y

Subscriptions, advertising and all business communications should be addressed

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227 South Sixth Street, Philadelphia, Pa

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